Bulletin 282 September 1931

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXPERIMENT STATION
IN CO-OPERATION WITH THE
UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL ECONOMICS

AN ECONOMIC STUDY OF CROP PRODUCTION IN THE RED RIVER VALLEY OF MINNESOTA

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UNIVERSITY FARM, ST. PAUL

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AN ECONOMIC STUDY OF CROP PRODUCTION IN THE RED RIVER VALLEY OF MINNESOTA

GEORGE A. POND, GEORGE A. SALLEE, and C. W. CRICKMAN

INTRODUCTION

The agricultural development of the Red River Valley began about 1870. Vast areas of virgin prairie were broken up by the early settlers and sown to wheat. Except for a small acreage of oats and barley, wheat was the only crop grown. As the soil was naturally very productive, wheat was grown continuously without careful preparation of the soil. In later years the production of oats and barley increased and flax was introduced. Crop rotation, however, was not practiced generally in the area, at least not for the purpose of conserving or improving the producing power of the soils. The growing of spring grains continuously on the same fields gradually subjected wheat growing to the usual hazards that accompany single-crop farming—declining productivity of the soil, increase of weed pests, the accumulation of plant diseases, and frequent ravages of insects, with attendant declines in yields. In the meantime, the spring-grain frontier was moving on farther west and northwest, where the industry of wheat growing was becoming established on a new physical and economic basis through the introduction of modern machinery, adapted especially to semi-arid farming.

The many natural hindrances to wheat growing, especially weeds, together with the increased competition from newer areas, are bringing about the introduction of additional cash crops to the Valley as well as crops that aid in controlling the weeds. As early as 1910 the acreage of wheat in the Valley had decreased fully 40 per cent below that recorded in 1900. The acreage of corn and potatoes has expanded rapidly during the last ten years or more; that of legumes, especially alfalfa and sweet clover, is increasing. Recently, sugar beets have become an important crop. With an increasing amount of feed crops to dispose of, there has been a strong impulse toward the development of livestock enterprises in conjunction with grain farming. Thus, a system of mixed farming is gradually displacing the old system, under which the farmer gave his attention almost exclusively to spring grains.

NATURE OF THE STUDY

In view of the transition which farming in the Red River Valley is undergoing and the widespread interest in the possibilities of making further adjustments in type of farming in response to changed physical

and economic conditions, a study of the agriculture of the region was begun in the spring of 1926 by the Minnesota Agricultural Experiment Station and the Bureau of Agricultural Economics of the United States Department of Agriculture.[1] The study was continued in 1927 and 1928. In addition to general observations and an interpretation of statistical information currently available, a detailed study was made of the organization and operation of a group of representative farms in Polk County. Complete records of labor and materials used in crop and livestock production, the production obtained, and the financial transactions of each farmer for each year were obtained to serve as the basis for judging the relative desirability of different combinations of crops and amounts of livestock, and the adjustments of these combinations to varying physical and economic conditions; and for studying the best methods of handling the crops and livestock in these combinations.[2]

The results of the study are reported in a series of three publications; this bulletin, "An Economic Study of Crop Production in the Red River Valley of Minnesota"; in Bulletin 283, "An Economic Study of Livestock Possibilities in the Red River Valley of Minnesota"; and in Bulletin 284, "Planning Systems of Farming for the Red River Valley of Minnesota," the problems that make necessary adjustments in the present systems of farming and the method of using basic farm organization data in planning and testing adjustments in the organization of individual farms, with illustrations.

The discussion of the data on crops is presented in six parts:

1. A description of the physical and economic factors affecting agricultural production in the Red River Valley.

[1] The authors wish to acknowledge assistance from the chiefs and members of the staff of the divisions of Agricultural Economics, Minn. Agr. Expt. Sta., and of Farm Management and Costs, Bureau of Agricultural Economics, in organizing and developing this study; and in reviewing and criticising the manuscript. Special credit is due to D. Curtis Mumford and Andrew T. Hoverstad, formerly members of the staff of the Division of Agricultural Economics, for their services in collecting and tabulating the data; to W. J. Roth, of the Bureau of Agricultural Economics, for his assistance in outlining and criticising the manuscript; to R. S. Dunham of the Northwest Experiment Station, Crookston, for his many helpful suggestions during the preparation of the manuscript; and to C. O. Ruud, who supervised the collection of the data in the field. The thanks of the authors and the divisions making this study are due the following farmers for their co-operation in furnishing the data upon which this bulletin is based: Ballantine Bros., John Bauer, Henry Beiswenger, William Beiswenger, Ole Bjorgo, W. F. Boltman, B. E. Bredlie, H. P. Briden, J. E. Briden, Roger Briden, A. P. Christiansen, Carl Christiansen, Artnur Eisert, Ole A. Flaat, G. L. Gibbons, Veral Gibbons, Andrew Hanson, Miner A. Helgeson, O. M. Kasburg, A. C. Linden, LaPlante Bros., Herbert Nissen, John Perry, Oscar Quarberg, August Ross, Otto Ross, Herman Skyberg, J. P. Tiernan, Harke Veldman, Martin Wagner, Earl Wardell, L. A. Wentzel, M. E. Wentzel, Wm. F. Wentzel, Wurden Bros.

[2] The complete cost route method was used in making the detailed study. Records were kept by the farmers whose business was studied under the supervision of a route man who visited each farm at regular intervals. This method is described in detail in Minn. Agr. Expt. Sta. Bull. 205, by G. A. Pond and J. W. Tapp; also issued as U. S. Dept. of Agr. Bull. 1271. 1923.

2. An account of the development of the agriculture of the area from the time of settlement, summarizing the changes in the relative acreages of the crops grown with some of the principal reasons therefor and showing geographically the present choice of crops, thus leading up to the present conditions under which crops are produced.

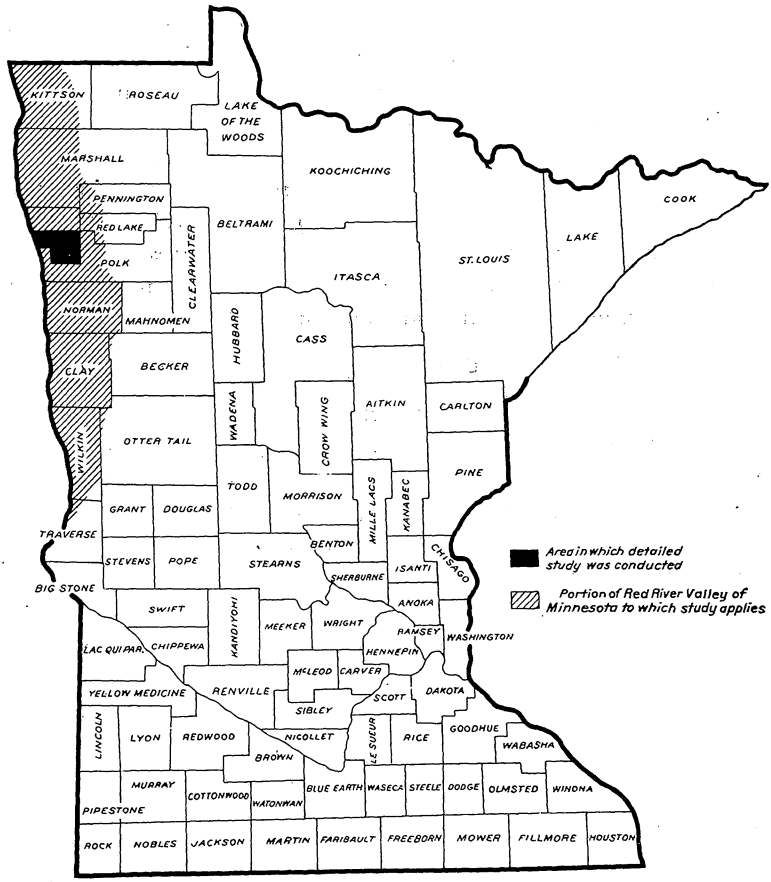

Fig. 1. Location of the Area Studied

The farms included in the detailed study were similar in type to the majority of farms located throughout the Red River Valley of Minnesota.

3. A discussion of the cropping problems that make necessary further adjustments in the cropping systems.

4. A detailed statement and analysis of the amount and distribution of man labor, power, and materials used in the production of the crops grown on the farms studied.

5. A discussion of the physical and economic relationships between different crops.

6. Some suggestions on the cropping systems.

DESCRIPTION OF THE RED RIVER VALLEY

The natural conditions of climate, soil, and surface, together with the location of the Red River Valley with reference to markets and the development of transportation, determine to a large degree the crops that can be grown there.

Topography

The Red River Valley in Minnesota is essentially a plain. It lies wholly within the region once covered by the waters of the ancient Glacial Lake Agassiz and except for the beach lines that mark the various stages of the ancient lake as it receded toward the north, the surface is flat, with barely perceptible depressions and low swells. The old beach lines, which occur in the eastern part of the area, consist of narrow ridges, varying from a few rods to about one-half mile in width and extending in a general north and south direction.

Drainage

Natural drainage of the area is for the most part poor. The tributaries of the Red River are shallow, winding streams with few branches. Bottom lands have not been developed by these streams except along the lower reaches. Narrow strips of land bordering the streams and coulees are usually fairly well drained, but artificial drainage is necessary on the greater portion of the level areas before they can be fully developed agriculturally. Away from the streams, water drains into the broad depressions from the surrounding country and collects, causing them to remain wet during the greater part of the spring.

Drainage ditches, with outlets into the principal streams or large coulees, have been opened through the extensive poorly drained districts, and excess water from the neighboring lands is carried to the big ditches by means of shallow lateral ditches, which are along the section lines. The laterals are usually too shallow, however, to drain thoroly the lands bordering them, for depressions lower than the level of the ditches frequently occur in the fields. More recently, highway ditches constructed in connection with road building have greatly aided drainage. Tile drainage is not practiced generally, altho it has been demonstrated on the Northwest Experiment Station farm, at Crookston, that tile drainage is effective wherever a satisfactory outlet can be obtained. Outlets are usually difficult to obtain, however, and frequently are to be found only at considerable distances from the land to be drained. Lack of adequate drainage remains one of the important limiting factors to a fuller agricultural development of the Valley.

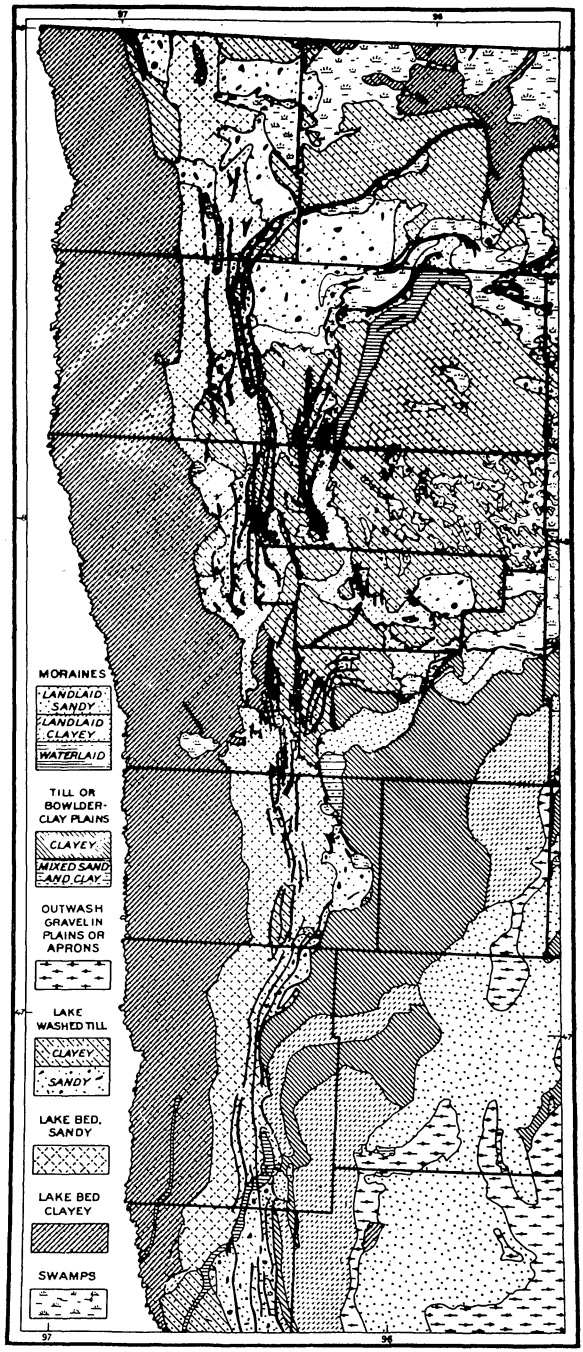

Fig. 2. Map of the Surface Formations in the Red River Valley and Adjoining Territories

The old beach lines of Lake Agassiz, indicated by the eel-like lines, mark the eastern boundary of the Red River Plain. (Adapted from map of the surface formations of Minnesota, by Frank Leverett, Geologist, United States Geological Survey.)

Soils

The soils of the Valley are lacustrine deposits derived from glacial drift, which was deposited in the basin and along the beaches of Lake Agassiz, or alluvial deposits laid down by the rivers after the glacial lake had receded northward. In general, they are of excellent quality for agriculture and well suited to cultivation when adequately drained.

The alluvial soils, covering a narrow strip near the Red River and widening out to a breadth of five to ten miles where the lateral streams empty into the Red River, are naturally well drained and among the most productive soils of the area. The top soil is dark brown to black silt loam, high in organic matter, and grades at about 15 inches into a highly calcareous subsoil of yellow silty loam, which becomes a gray silty clay at a depth of 3 to 5 feet below the surface. This soil is easily cultivated and breaks up into a loamy, friable condition; the silty texture, together with the large proportion of organic matter, giving it a very desirable tilth.

Eastward, beyond the alluvial soils, a clay belt with an average width of about fifteen miles, extends the length of the Valley. These black silty clay or clay loam soils underlain by a gray to drab calcareous silty clay are lacustrine deposits and form one of the most extensive soil types in the Valley. A relatively large quantity of organic matter in the surface makes this soil friable and easily cultivated when dry but very sticky and tenacious when wet, making plowing during wet seasons difficult. As a whole natural drainage is very poor, but the drainage of the soil has been improved greatly during recent years by extensive ditching. In some of the extensive poorly drained areas deposits of peat are found. Some accumulation of alkali occurs in small spots, usually in wet places; but better drainage usually will free these spots from excessive amounts of soluble salts. In limited areas the ground water is strongly impregnated with alkali salts, making it unfit for drinking purposes for both men and animals. In these areas it is necessary to impound either melted snow or rain water in artificial reservoirs to supply livestock and in cisterns for household use. When well drained, the clay loam is one of the best soils in the Valley for general farming purposes.

Between the old beaches on the east and the belt of clay loam on the west, the soil is a fine to very fine sandy loam, dark brown to black. The subsoil to a depth of 25 inches is gray to brown, sticky, fine sandy loam, usually containing more silt than the surface soil. It grades at the average depth of 25 inches into a fine yellow to gray sand. This soil is easily cultivated and can be plowed much earlier in the spring and after heavy rains than the heavier soils. Clods formed when the soil is plowed in a wet condition do not become hard and the surface is easily reduced to a good state of tilth.

The sandy loam area occupies a position slightly higher in the old lake basin and, with the sandy texture of both soil and subsoil, it is naturally better drained than the clay loams. Crops grown on it are not so seriously damaged by heavy rainfall. In the spring of the year, however, the level of the ground water is seldom more than 3 feet below the surface and some of the shallow depressions frequently remain in a cold wet condition for a considerable length of time, tho the surface water drains off more rapidly than where the subsoil is heavier.

Interspersed in the fine sandy loam areas and especially near the old beaches are smaller areas of similar surface soil but underlain with beds of gravel, which usually occur at a depth of 30 to 36 inches, tho sometimes nearer the surface. These areas are characterized by numerous small shallow depressions that are difficult to drain, and even the better drained portions are not productive in a dry season. The difficulty of draining a soil of this type, together with the poor moisture conditions in dry seasons, makes it of little agricultural value except for pasture and wild hay.

All the cultivated soils of the Valley are naturally rich in plant food elements, and do not require limestone for growing legumes. Fields that have been subjected to years of continuous grain growing respond markedly to crop rotation, the use of legumes, and better cultural methods; but the average farmer in the Red River Valley does not find it generally profitable to use commercial fertilizer except in the form of superphosphate applied to alfalfa and sugar beets. Phosphate fertilizers have been found profitable on potatoes in some places. Other common crops have not always responded profitably. Additional sulphur is not needed and the supply of potash is adequate for all crops with the possible exception of sugar beets in limited areas. The clay soils have become compact through misuse and are benefited by good cultural practices and the addition of humus-forming materials.

Climate

The climate of the Valley is characterized by a relatively low annual rainfall, a short growing season, and a wide variation in temperature between winter and summer. The mean annual precipitation ranges from about 20 inches in the northern counties to 26 inches in Wilkin County. However, the greater part of the rainfall occurs in the late spring and early summer—the time of greatest benefit to crops grown on well drained land. On the whole, the distribution of the rainfall is such that serious droughts are of rare occurrence. On the other hand, the large amount of rainfall in May and early June frequently delays seeding and at times causes the poorly drained sections of the land to remain too wet for cultivation until too late in the season for any crop on them to mature.

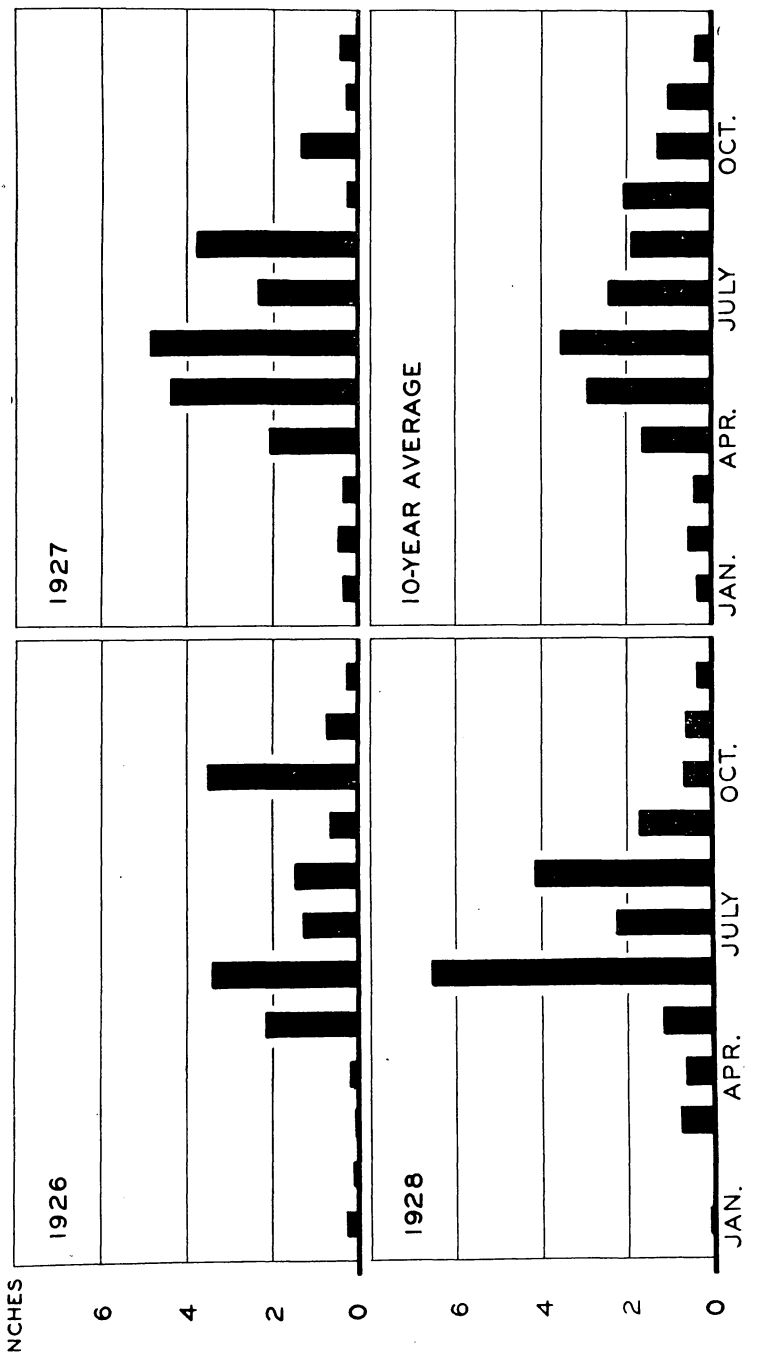

Fig. 3. Monthly Precipitation at Crookston, 1926-28 and 10-Year Average

The greatest part of the annual rainfall occurs in the late spring and early summer; the time of the greatest benefit to crops grown on well drained land.

The winters are long and cold. The soil freezes, usually, in November and remains frozen, under a cover of snow, until March or April. The farming season is short, but the cool, moist spring, merging gradually into hot summer days with the 14 to 16 hours of sunshine, favors the quick growth and maturity of crops (see Fig. 3). Warm south and southwest winds with frequent showers are other favorable factors. The falls are marked by little rainfall and by cold frosty nights. Some warm Indian Summer days are favorable to the harvesting of crops and to fall plowing.

Table 1, compiled from the records of the Weather Bureau Station, at Crookston, gives climatological data recorded at approximately the geographical center of the Valley.

Table 1

Climatological Data from the United States Weather Bureau Station at Crookston, Minnesota

	Average	Range	Years of study		
			1926	1927	1928
Presipitation, in.*	20.30	9.27–29.60	13.99	20.94	18.99
Precipitation, in., Apr.1-Sept. 30*	15.53	6.08–24.03	9.15	17.71	16.46
Mean annual temperature, deg.†	39.01	36.08–41.57	39.83	38.06	41.57
Mean winter temperature, deg.†	19.41	14.73–23.58	19.80	19.27	20.20
Mean summer temperature, deg.†	58.57	53.77–61.60	58.90	57.67	57.77
Minimum temperature, deg.† ...	−32	−23 – −39	−25	−32	−23
Maximum temperature, deg.† ...	96	88– 108	97	91	94
Number of frost-free days*	126	78– 171	113	133	112
Last killing frost in spring*	May 20	Apr. 20–June 9	May 22	May 15	June 3
First killing frost in fall* ...	Sept. 23	Aug. 26–Oct. 26	Sept. 12	Sept. 25	Sept. 23
Direction of prevailing wind* ..	South	.....	South	North	North

* Records for 30 years.
† Records for 20 years.

Adaptation of Crops

Because of the cold, dry winters and short, frost-free growing seasons, grain crops are best adapted to the region—spring wheat, barley, oats, and flax, which are seeded in the spring and harvested in the late summer or early autumn after a growing season of from 100 to 130 days. The Red River Valley has long been noted for the high quality of its potatoes. The Early Ohio variety is well suited to the heavy soils; Irish Cobbler and Bliss Triumph to the sandy and sandy loam soils. Rye and buckwheat are grown on only the sandy soils. Emmer, commonly called spelt, is adapted to the conditions but is seldom grown. The growing season is short for corn. However, if the season is not too unfavorable, early-maturing varieties can be ripened and corn for ensilage is grown without difficulty. Sugar beets and the feed root crops, as mangles, rutabagas, and turnips, yield well.

The clovers, alfalfa, and meadow fescue grow abundantly without the use of limestone. These crops frequently winter kill, but this diffi-

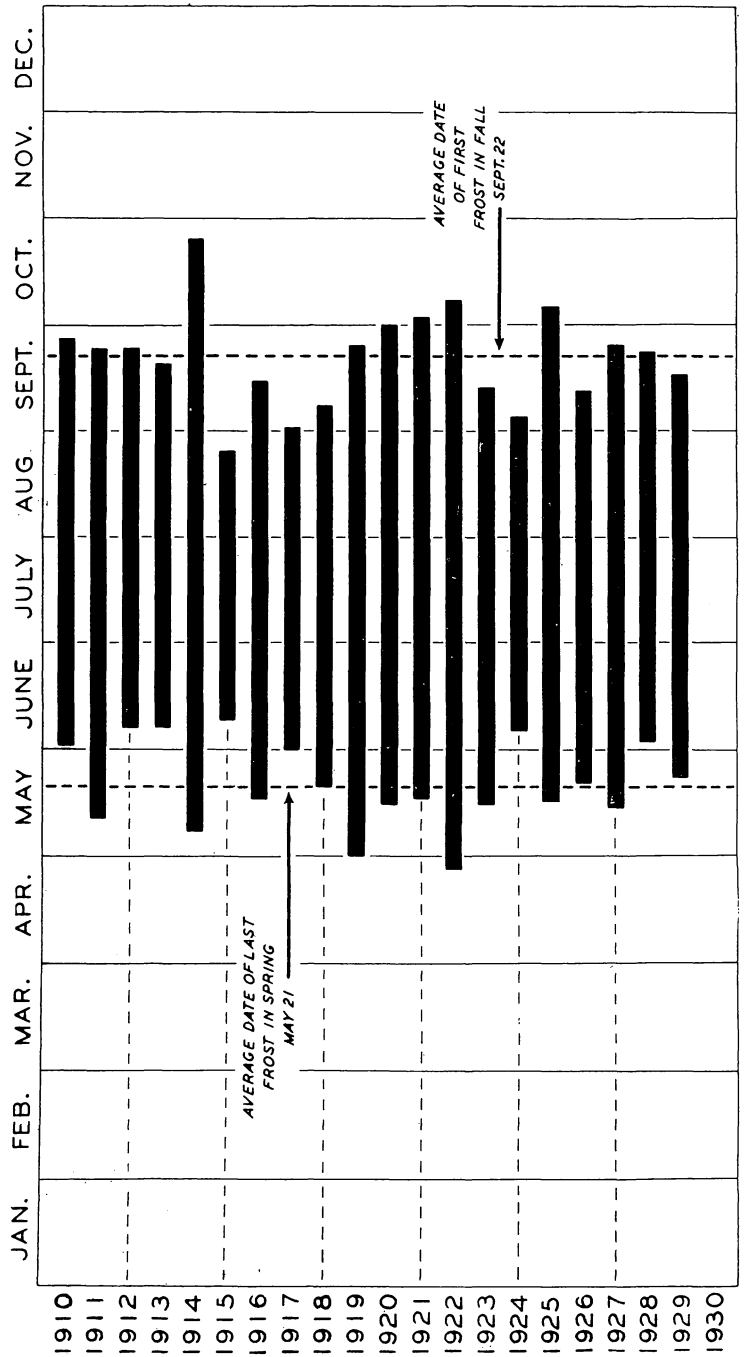

Fig. 4. Growing Season in the Red River Valley, by Years, 1910-1929, Inclusive

The length of the bars represents the period between the last killing frost in the spring and the first killing frost in the fall, according to data recorded by the United States Weather Bureau Station located at Crookston.

culty can be largely overcome by careful handling. Brome grass produces good pasture. Timothy is grown for both hay and seed. The native grasses largely are bluegrass, bluejoint, wild cereal grasses, and marsh grasses.

A wide variety of garden crops of high quality can be grown and most of the small fruits, as plums, raspberries, gooseberries, currents, and strawberries are well adapted to the Valley. Onions are grown commercially in limited areas.

Crop Yields

Yearly average yields for the last ten years of the crops commonly grown in the Valley are shown in Table 2. In general, crop yields are much below the potentialities of the soil and climatic resources. Better yields are possible through more careful farming, on the majority of farms. This is demonstrated by the yield trials conducted at the Northwest Experiment Station, at Crookston (see Table 3), and is confirmed by the experience of farmers who have freed their farms of weeds and improved the soil with a rotation of crops that includes a legume.

Table 2

Yearly Average Yield per Acre of Specified Crops Grown in the Red River Valley 1919-28 and 10-Year Average*

	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	10-year average
Wheat, bu.	9	8	9	14	10	20	11	13	10	14	11.8
Oats, bu.	24	33	18	31	26	36	33	25	19	32	27.7
Barley, bu.	20	25	17	26	21	29	25	23	25	26	23.7
Flax, bu.	8	8	9	9	8	10	7	9	6	6	8.0
Corn, bu.	36	26	35	29	30	25	24	27	10	30	27.2
Rye, bu.	15	15	14	17	9	19	11	13	15	14	14.2
Potatoes, bu.	86	91	103	88	102	105	80	93	89	99	93.6
Tame hay, tons	...	1.6	1.4	1.4	1.2	1.5	1.7	1.3	1.7	1.6	1.5
Wild hay, tons	....	1.3	0.9	1.0	1.0	0.9	1.1	1.0	1.3	1.0	1.0

* Compiled from the annual crop reports of the Minnesota State Dept. of Agr. by averaging the reported yields for Clay, Kittson, Marshall, Norman, Pennington, Polk, Red Lake, and Wilkin Counties.

In Table 3 are shown the average yields of specified crops grown in field trials at the Northwest Experiment Station, together with yields obtained by farmers co-operating in the special study made in Polk County. The yields shown for the farms studied are 3-year averages of the highest yield in the lower three-fourths of the range of yields obtained each year on all farms. These yields in both instances were obtained under farm conditions and represent a conservative measure of the possibility for better yields in the Valley.

Table 3

Aveerage Yields of Specified Crops Grown in Field Trials at the Northwest Experiment Station, Crookston, and on Certain Farms Studied in Polk County*

Crop	Northwest Experiment Station		Farms studied	
	Period of record	Average yield*	Period of record	Average yield
		bu.		bu.
Wheat	1921-27	18.7†	1926-28	19.7
Barley	1921-27	34.6	1926-28	32.5
Oats	1921-27	59.1	1926-28	43.8
Flax	1923-27	12.4	1926-28	7.8
Potatoes	1926-27	120.2‡	1926-28	123.8
		tons		tons
Corn silage	1926-27	6.9	1926-28	4.3
Alfalfa	1923-27	3.3	1926 28	1.6
Beets	1927	13.5	1926-28	11.1

* Compiled from the Annual Report of the Northwest Experiment Station. Crookston, for 1927.

† Weighted average of yields of Marquis and Mindum varieties.

‡ Average yield on 3-year rotation plots.

Transportation and Markets

The Red River Valley is well supplied with direct rail transportation to Minneapolis, Duluth, Winnipeg, and the Pacific Coast. Practically all the wheat, barley, oats, and flax marketed moves eastward through Minneapolis and Duluth. Potatoes of the Irish Cobbler and Bliss Triumph varieties are distributed through local dealers into Kansas and the Southwest; the Early Ohio variety finds a market principally in Illinois and Iowa. Surplus livestock is marketed directly to packing plants located at Grand Forks and Fargo, North Dakota, or shipped co-operatively to South St. Paul. Co-operative creameries are distributed throughout the Valley, but, on the whole, concentration of the production of dairy products is not sufficient to justify a creamery in every community. For the most part, dairy products are marketed as sour cream to the large centralizer creameries in the larger towns. The American Beet Sugar Company erected a beet sugar factory at East Grand Forks in 1925, which manufactures into sugar the beets grown in the Valley. This company has placed loading facilities at railway sidings wherever a sufficient tonnage can be obtained.

AGRICULTURAL DEVELOPMENT OF THE RED RIVER VALLEY

A knowledge of the changes that have taken place in the cropping systems in the Red River Valley, together with the principal reasons for these changes, furnishes an explanation of why the present cropping system has become what it is. The reasons are to be found in the natural conditions of the land, the accessibility to markets, the prog-

ress of farming practice, and the accumulation of capital at different stages in the agricultural development of the region. They are also to be found in the relative prices that could be obtained for the various crops to the production of which the resources of the Valley are fitted. Readjustments in the cropping systems seldom keep pace with the forces operating to make further changes desirable. The reasons for the readjustments apparent in recent years, therefore, together with a description of the cropping systems, become the basis for the study of present maladjustments.

History of Settlement

A few pioneer farmers settled in the Red River Valley prior to 1870. They found the winters too severe for growing winter wheat; and spring wheat, altho it was adapted to the region, was marketable only at a relatively low price. The early American milling process left spring wheat flour dark, and the dark flour did not sell readily in competition with white winter wheat flour. It was not until 1870 that the milling process for making Minnesota Patent flour was introduced. Thereafter spring wheat commanded a premium over winter wheat on a ready market, and a tide of immigration moved into the Valley to grow spring wheat. In 1871 two railroads were extended to the southern end of the Valley—the St. Paul and Pacific to Breckenridge and the Northern Pacific to Moorhead—to carry immigrants to the Valley and wheat to market. A period of rapid agricultural development followed. The Valley was well adapted, physically, to large-scale farming operations and the development of new machinery about this time made extensive grain farming possible. Settlement had extended to the Canadian border in 1880, and by 1900 farming had expanded over the entire Valley. In 1900, 62 per cent of the land area was in farms, with approximately 71 per cent of the farm area improved (see Table 4). With the larger part of the more accessible farm lands of the Valley settled, expansion was halted during the next decade; but it continued during the period 1910 to 1920 under the stimulus of the war-time demand for wheat. Since 1920, however, much of the new land drawn into cultivation during the period of war prices has been abandoned.

Table 4

Progress of Agriculture in the Red River Valley of Minnesota, 1870 to 1925 (U. S. Census)*

Year	No. of farms	Acres of land in farms	Percentage of total land area in farms	Percentage of total farm land improved	Value per acre of land and buildings	Percentage of farm land in crops, exclusive of wild hay	Population
1870	.....	9,892	0.2	9.5	$ 2.63	...	199
1880	3,142	701,468	12.8	18.3	7.94	10.6	10,918
1890	10,626	2,207,841	40.5	54.8	10.26	37.5	36,585
1900	14,504	3,499,134	62.3	69.4	15.85	46.0	112,338
1910	13,004	3,497,612	64.2	74.2	25.42	47.9	120,097
1920	15,485	4,228,157	77.3	78.4	68.00	53.4	133,372
1925	15,815	3,957,230	72.6	79.5	49.10	54.8	.....

* Compiled by combining census data for Clay, Kittson, Marshall, Norman, Pennington, Polk, Red Lake, and Wilkin Counties.

Changes in Acreage of the Principal Crops

On the whole, the trend in the percentage of crop land devoted to wheat has been downward since 1890 (see Fig. 5). With few exceptions the trend in the acreage of oats and barley has been upward. Flax, in its general movement northward and westward, passed through the Valley during the 10-year period 1900 to 1910. Recently there has been a renewed interest in flax. Virtually no rye was grown in the Valley until about 1910, when farming expanded into the sandy areas. While it has been one of the principal crops grown in these areas, it is not one of the important crops of the Valley as a whole. Previous to 1910 few potatoes were grown, and not until 1920 was there much increase in acreage outside of Norman and Clay Counties. The acreage of corn increased rapidly after the war until 1924, with some reaction later. The southern counties began to grow corn earlier and the increase there has been more rapid, especially corn for grain. It has been only during the last few years that corn has been grown as far north as Kittson County. Sweet clover, alfalfa, and sugar beets have become important crops in the Valley during the last 10 years and the acreage of each is increasing.

During the period of expansion and development, wheat and oats were practically the only crops grown in the Valley, with approximately 80 per cent of the crop land devoted to wheat. Capital was scarce and farmers were compelled to concentrate their efforts on the crops that promised cash returns in the shortest possible time. The relative extent of the wheat acreage from year to year depended upon the character of the spring season. When field work could be done early in the spring, the maximum acreage of wheat was sown; if the season was late, oats, barley, and flax were grown more extensively, as they can be seeded later and still mature before frost.

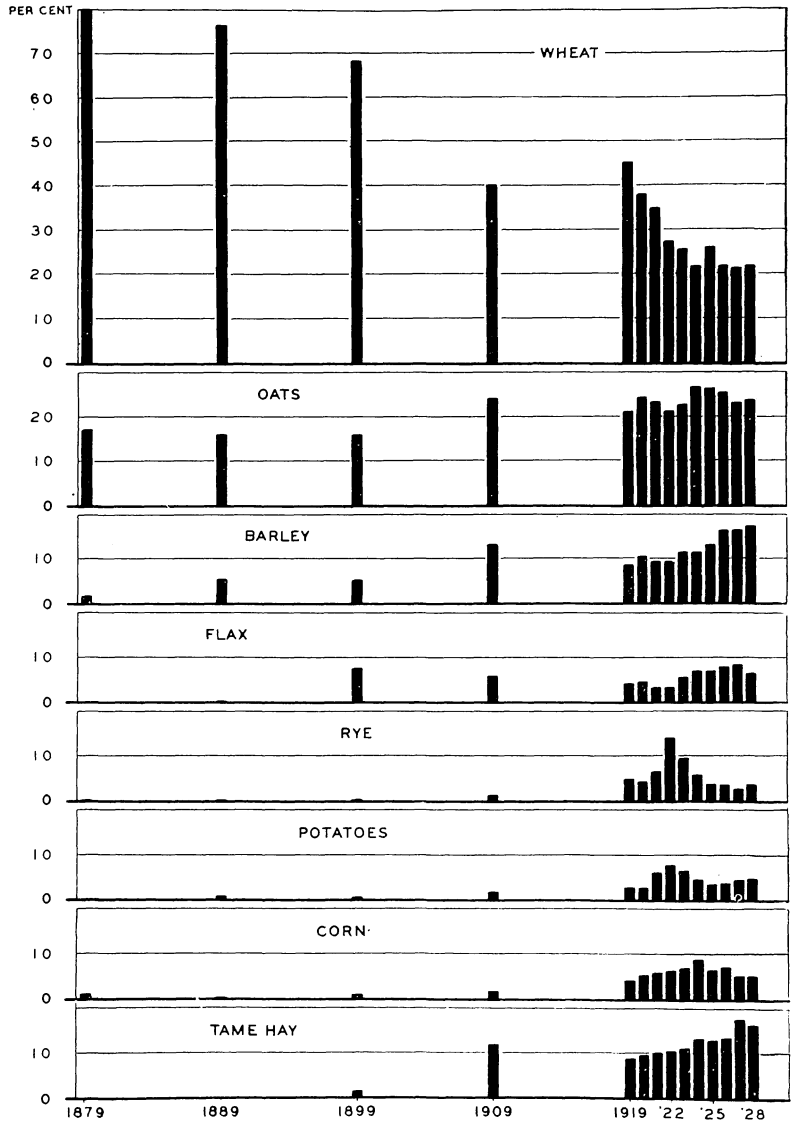

Fig. 5. Changes in the Choice of Crops in the Red River Valley, 1879-1928, as Shown by the Percentage Distribution of Total Acreage of Seeded Crops

The trend in the percentage of crop land devoted to wheat has been downward; that in the percentage devoted to feed crops, has been generally upward.

The practice of growing wheat on approximately 80 per cent of the cropped area during the first 30 years of farming in the Valley developed unfavorable soil conditions, weed pests, and plant diseases, and the attempt to control these conditions during the last 30 years has been largely responsible for the changes since 1900. Black stem rust, the most destructive cereal disease in the spring wheat area, and weeds such as sow thistle, Canadian thistle, and quack grass have been important factors contributing to the rapid decline in wheat acreage since 1900. The reduced yields and the uncertainty of the wheat crop as a result of these unfavorable conditions caused farmers to shift first to more oats and barley, then gradually to inter-tilled crops in an attempt to improve the physical condition of the soil and to eradicate the weeds (compare Tables 2 and 3).

Between 1899 and 1909 wheat was displaced rapidly in the cropping system by barley and oats. During this 10-year period the acreage of wheat decreased from approximately 70 per cent of the total acreage in crops to 40 per cent. The absolute decrease in acreage was 37 per cent. On the other hand, oats and barley each increased relatively 8 per cent. The rate of expansion of the acreage of corn increased slightly, especially in Wilkin County, and the acreage of potatoes likewise increased, chiefly in Clay County. Potatoes were the only cultivated crop known to be well adapted to Valley conditions when the movement toward cultivated crops was begun. A crop of potatoes grown ahead of a grain crop improves the physical condition of the soil and to a considerable extent cleans the land of weeds. Potatoes are also a substitute for wheat as a cash crop. The heavy labor demands, however, limit the acreage that can be grown without providing extra labor, and the total acreage in the Valley is still relatively small, notwithstanding the fact that potatoes of very high quality can be grown.

Conditions of the war period were reflected in the relative crop acreages in 1919. The acreage of barley and oats, especially of barley, was decreased to grow more wheat, and, to a minor extent, rye (see Fig. 5). Immediately following 1919, however, there were marked yearly decreases in both the relative and the absolute acreage of wheat. Within the next 4 years the acreage of wheat decreased relative to other crops 20 per cent and absolutely 54 per cent. This rapid decline in the acreage of wheat and the increase in the acreage of feed crops after the war was a readjustment to the trend toward mixed farming, which war-time conditions interrupted. The rate of this readjustment was greatly stimulated by the relatively low price of wheat during the period immediately after the war. The general policy of the farmers

in recent years has been to rotate sweet clover and cultivated crops on an increasing proportion of the farm in order to improve the fertility and physical condition of the soil and clean the land of weeds. Since 1924 wheat has continued to occupy about 22 per cent of the combined acreage devoted to all crops; the acreages of barley, corn, and potatoes have steadily increased in proportions. The relative proportion of the crop land devoted to hay has doubled during the last 10 years.

The adaptation of crops to adverse conditions, through the development of new varieties, has been an important factor in affecting recent changes in acreage. The introduction of the Grimm variety has eliminated much of the risk of winter-killing of alfalfa. The development of earlier maturing varieties of corn made possible an increase in corn acreage following 1920. Furthermore, farmers are learning to substitute barley for corn in feeding. The reduction in the acreage of corn since 1925 was the result of a succession of three poor corn seasons, beginning in 1924. Wilt-resistant varieties of flax, first developed about 1913, have made it possible to grow flax on old land. Much of the renewed interest in flax, however, was due to its favorable market position created by an increased world demand and the enactment in 1922 of a tariff of 40 cents per bushel on flax seed. In 1930 the tariff was raised to 65 cents per bushel.

Because of the favorable price of rye compared with that of wheat the acreage was more than doubled in 1921.

The problems of crop risk and better labor distribution also were involved in the movement toward a rotation of crops and diversification with livestock. With the system of specialized wheat farming, the seasonal distribution of labor is very uneven and unsatisfactory. Peak loads come in the spring at plowing and seeding time and again in harvest time. Extra labor must be employed at high wages. During the winter, on the other hand, the farmer who grows little else than wheat and spring grains has little to do. Obviously, if a man works only half a year he can not expect to do as well as if he worked a whole year.

Present Cropping Systems

The cropping systems in the Red River Valley continue to be primarily combinations of the spring grains, notwithstanding the recent increase in acreage of such crops as corn, potatoes, sugar beets, and alfalfa. In Figures 6, 7, and 8 are shown the choices made by farmers in different parts of the Valley between the various seeded crops for 1927.[3] Figure 6 shows the first choice by township as indicated by the

[3] The Minnesota State Farm Census was the source of data for these figures and others following in which are shown the percentage, by townships, of all farm land devoted to various uses.

crop occupying the largest percentage of all farm land. Figure 7 shows second choice, or the crop occupying the second largest percentage, and Figure 8 shows third choice. The choice of crops is the result of the interaction of all the various physical, biologic, and economic factors affecting production on the farm. However, Figure 2 shows a high degree of similarity between the boundaries of the cropping areas, as shown in Figures 6, 7, and 8, and the lines dividing the different soil types. In general, wheat is the principal crop on the better drained. heavy soils high in organic matter. Barley can be grown on poorer soils with profit, and has the additional advantage of a later seeding date, which makes it adaptable to poorly drained, heavy soils which remain wet until late in the spring. Oats, being less exacting as to soil than any of the other cereals except buckwheat and rye, occupy first place on the lighter sandy soils, and rank next to wheat in the border zone between the clay and the sand belts. The interspersion along the eastern border of glacial clay soils, which are often poorly drained and frequently not adapted to crops other than hay, results in tame hay occupying an important place there.

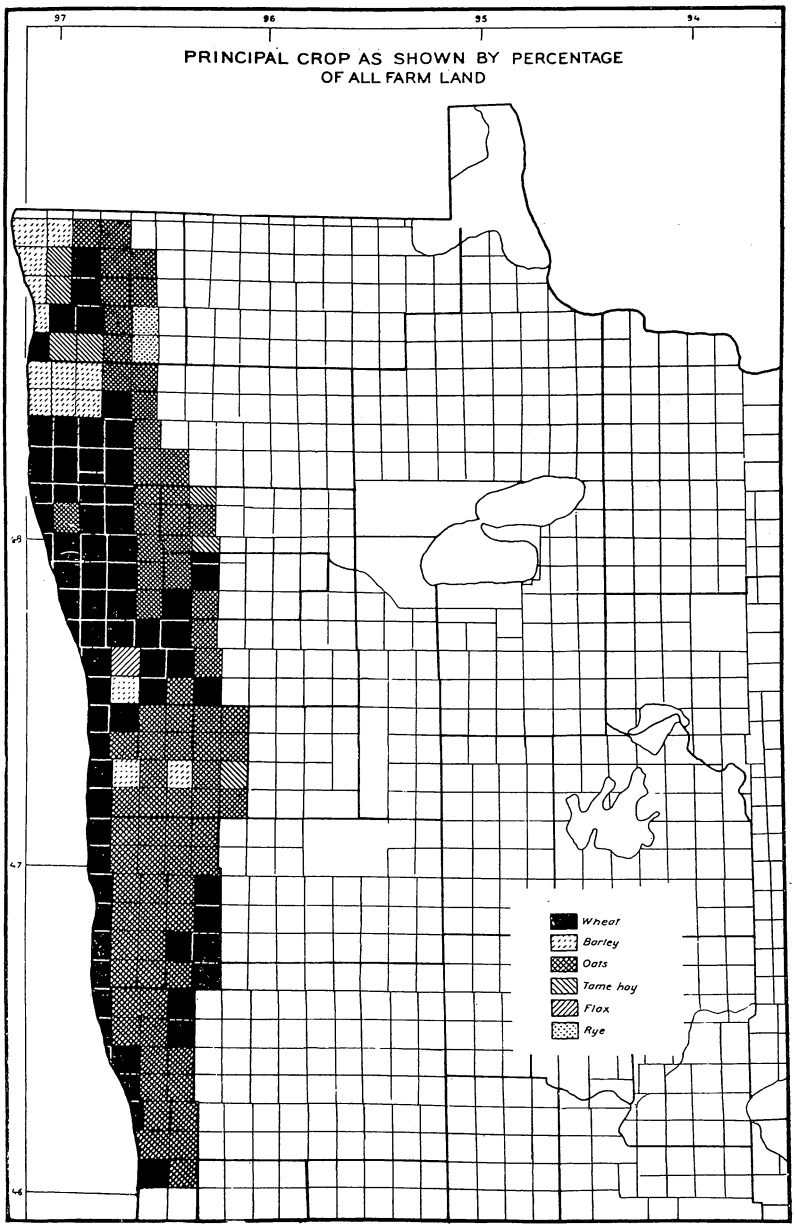

Fig. 6. First Choice of Seeded Crops as Shown by Acreage in 1927, by Townships

Wheat is the principal crop grown on the better drained, heavy soils, high in organic matter. Oats, being less exacting as to soils than most other crops, occupy first place on the light sandy soils.

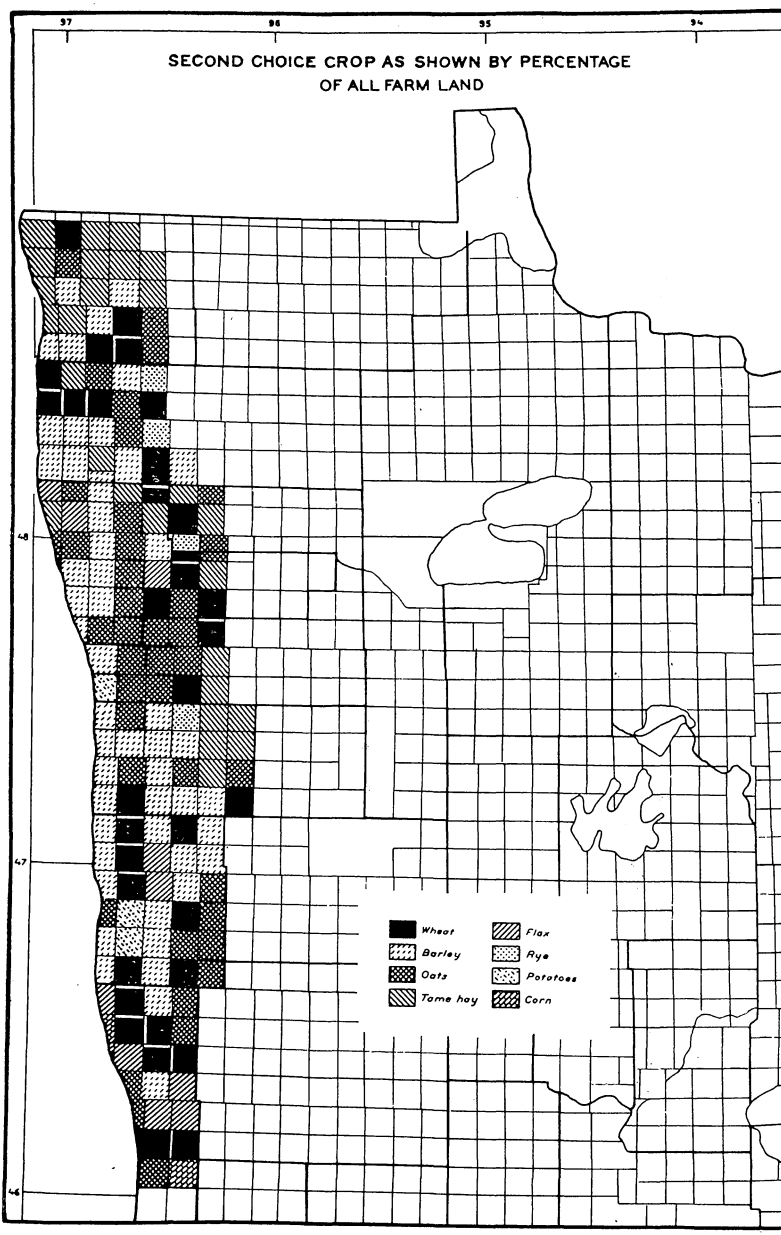

Fig. 7. Second Choice of Seeded Crops as Shown by Acreage in 1927, by Townships

Barley generally can be grown with profit on poorer soils than can wheat, and barley has the additional advantage of a later seeding date, which makes it more adaptable to poorly drained, heavy soils that remain in a wet condition until late in the spring.

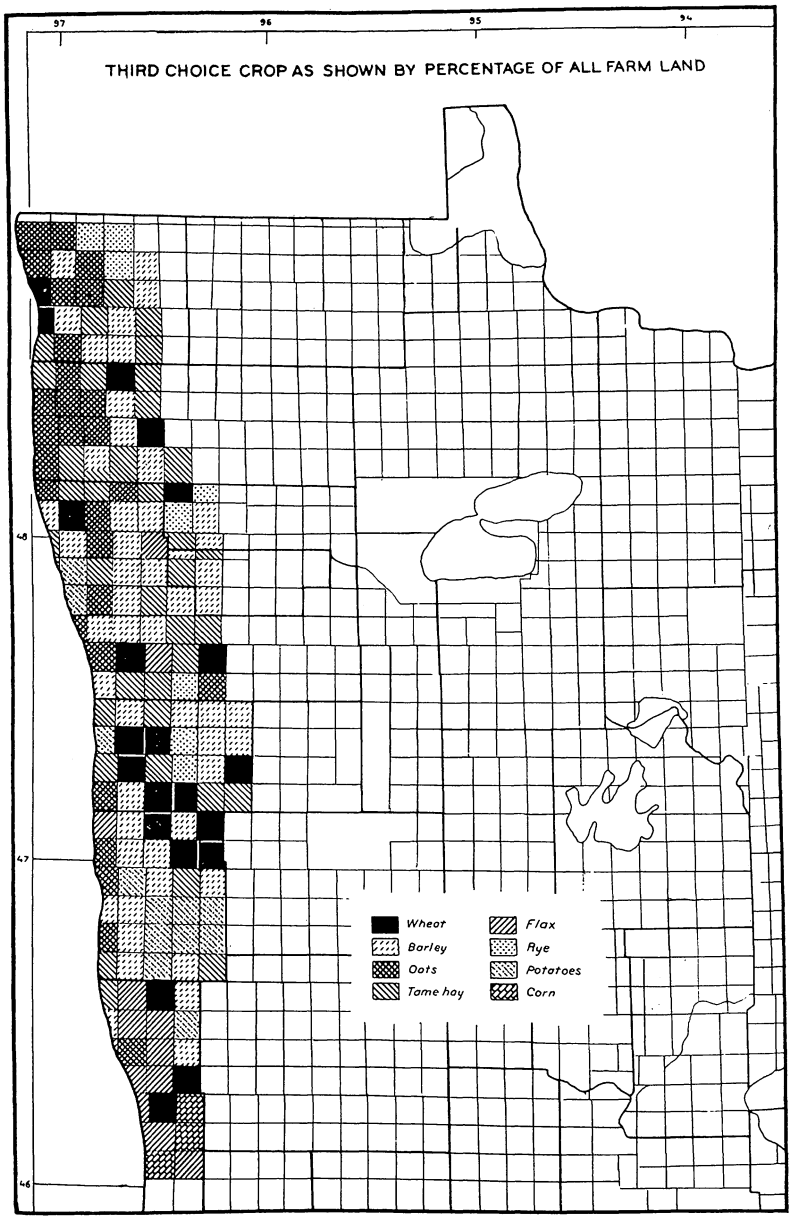

Fig. 8. Third Choice of Seeded Crops as Shown by Acreage in 1927, by Townships

Minor differences in physical and economic characteristics of different parts of the Valley, while having little influence upon the selection of the leading crops, had a noticeable influence upon the selection of the third most important crop.

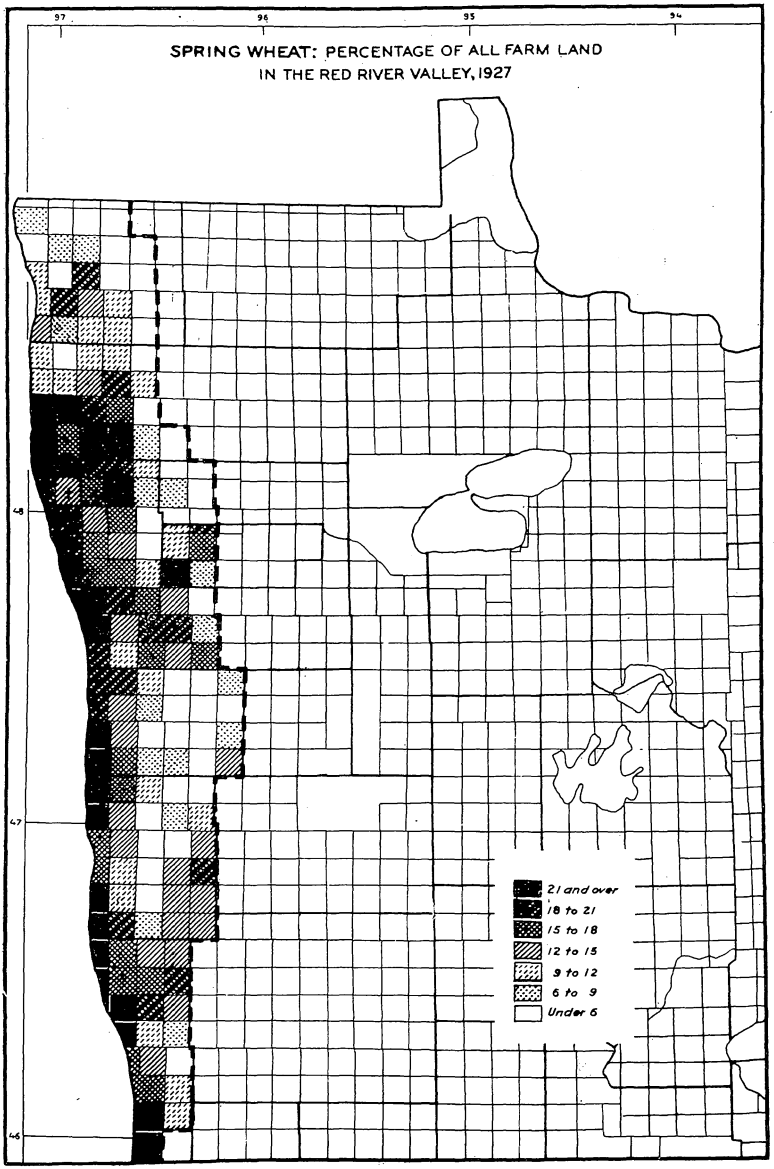

Fig. 9. Percentage of All Farm Land in the Red River Valley in Wheat, 1927, by Townships

Wheat requires well drained land, as indicated by the extensive acreage in the townships nearest the Red River.

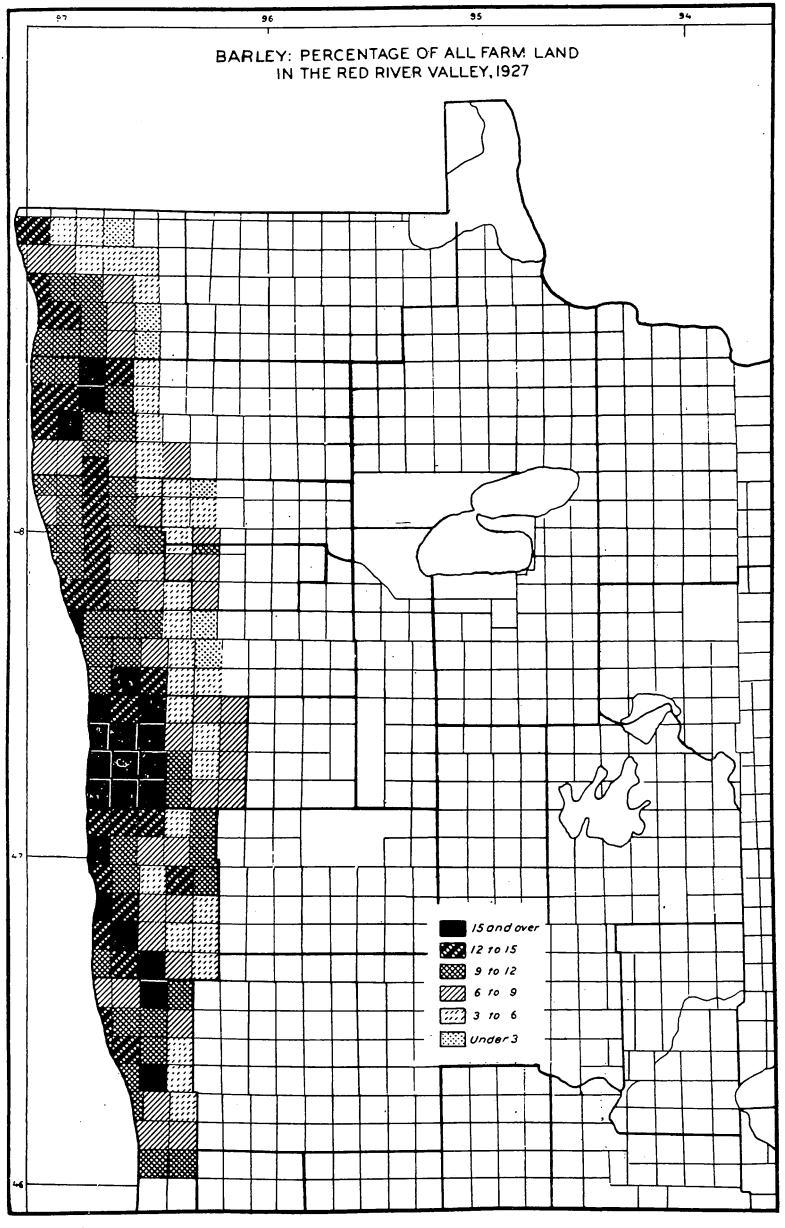

Fig. 10. Percentage of All Farm Land in the Red River Valley in Barley, 1927, by Townships

The production of barley is more uniformly distributed throughout the Valley than that of any other crop.

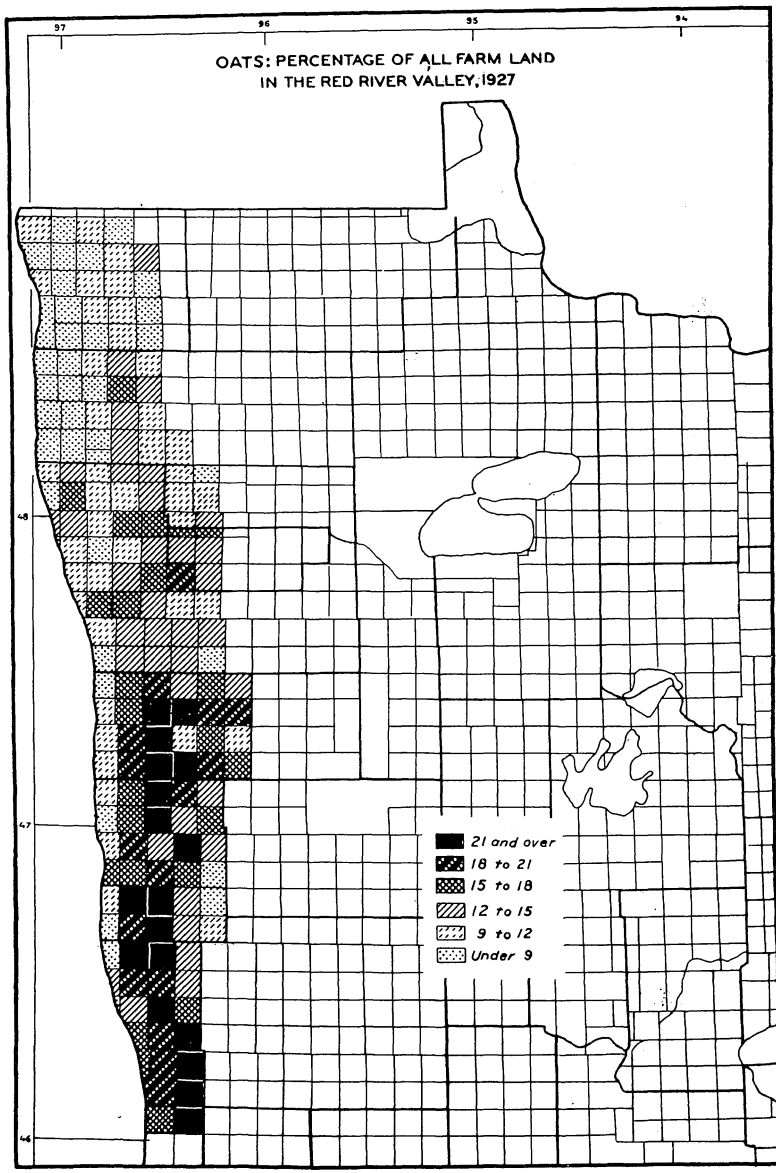

Fig. 11. Percentage of All Farm Land in the Red River Valley in Oats, 1927, by Townships

Oats are grown extensively throughout the Valley with a heavy concentration of acreage on the sandy strip in the southern half.

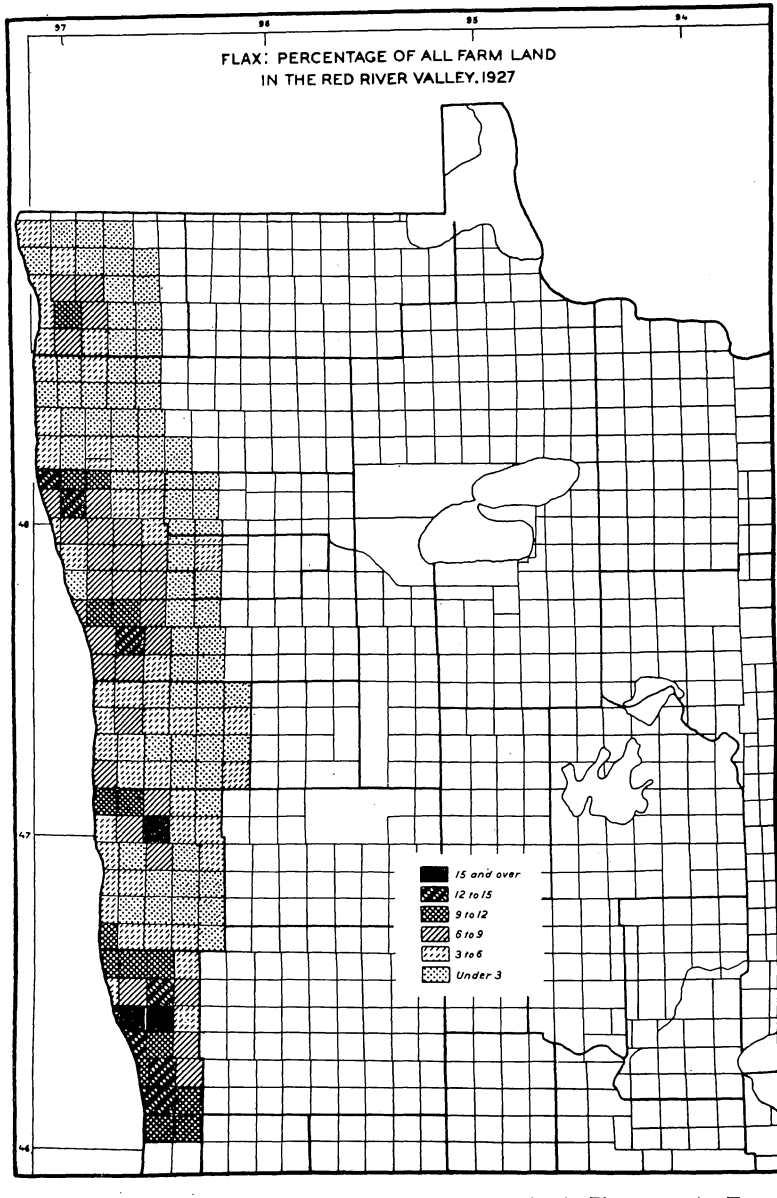

Fig. 12. Percentage of All Farm Land in the Red River Valley in Flax, 1927, by Townships

Flax is commonly grown on new land, or old land that has been well cleaned of weeds.

Fig. 13. Percentage of All Farm Land in the Red River Valley in Corn, 1927, by Townships

Climate is the principal limiting factor in corn production in the Red River Valley.

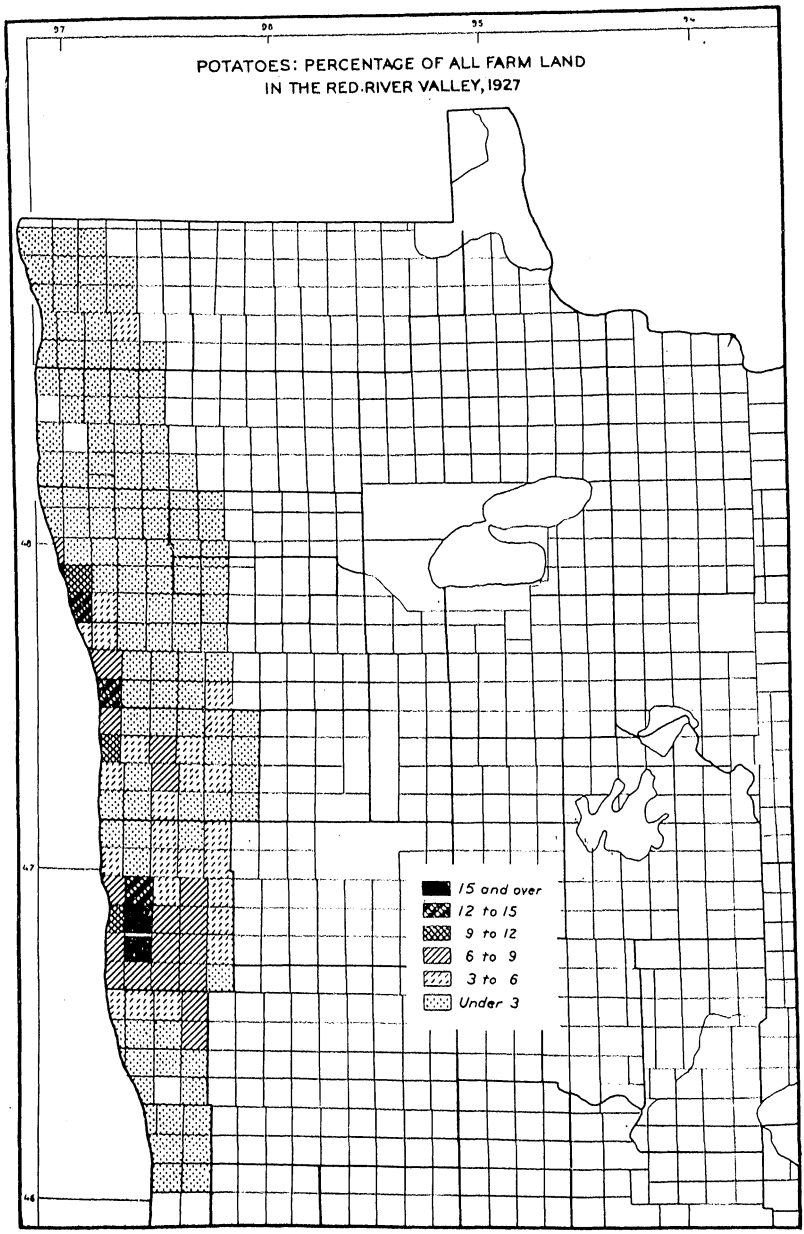

Fig. 14. Percentage of All Farm Land in the Red River Valley in Potatoes, 1927, by Townships

Potatoes are an important crop in Clay County and along the Red River in southern Polk and northern Norman Counties.

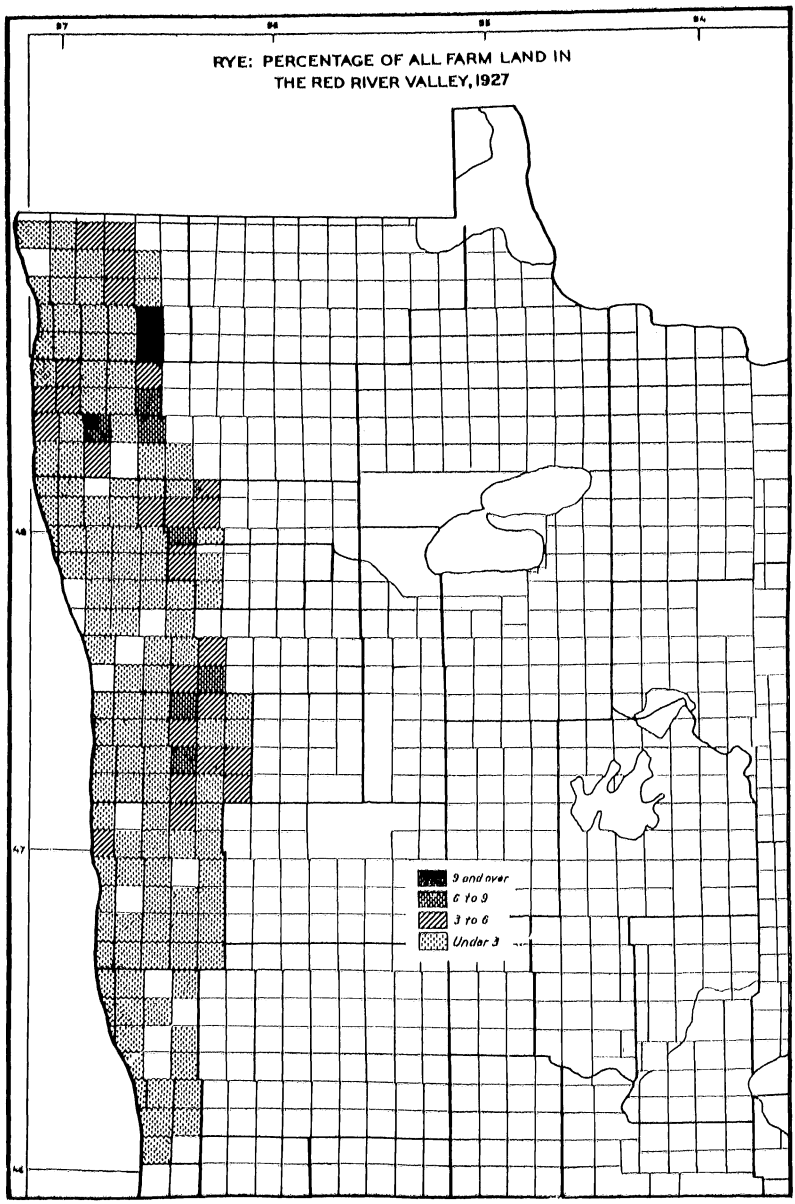

Fig. 15. Percentage of All Farm Land in the Red River Valley in Rye, 1927, by Townships

Rye is one of the principal crops grown on the light sandy soils. It is not, however, one of the important crops of the Valley as a whole.

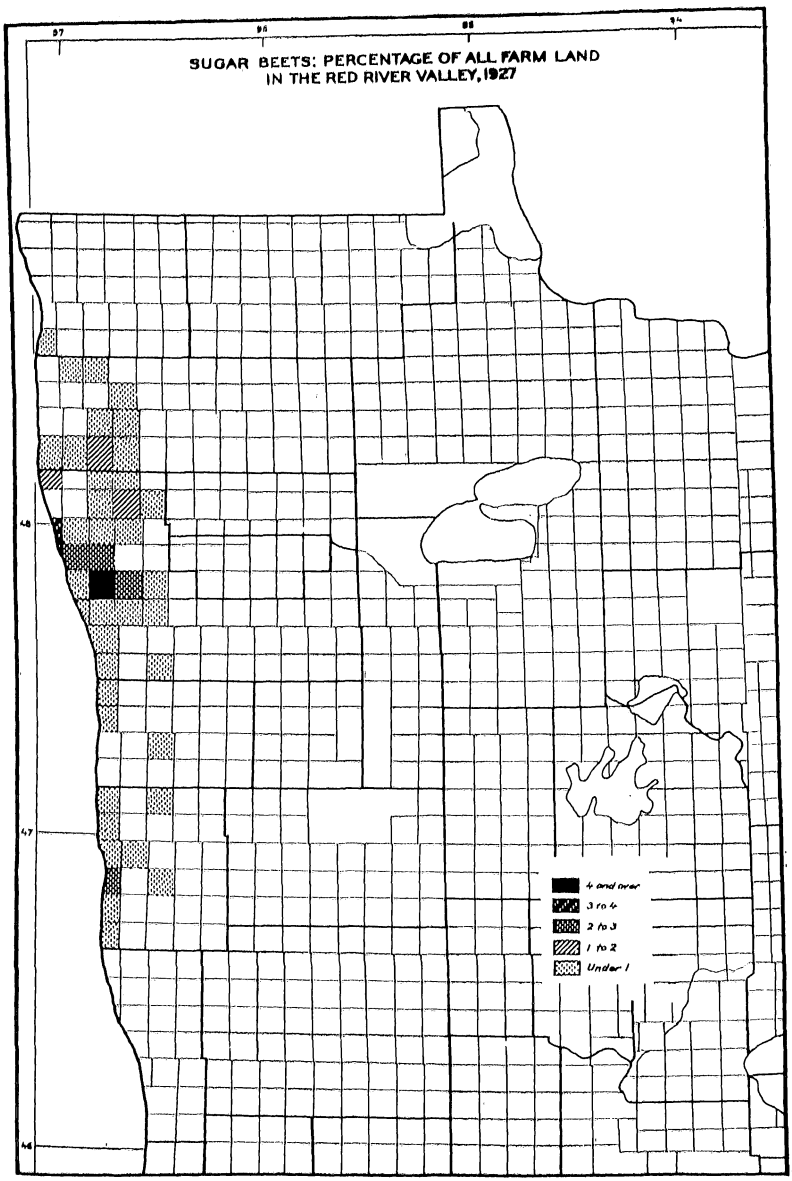

Fig. 16. Percentage of All Farm Land in the Red River Valley in Sugar Beets, 1927, by Townships

Sugar beet production is scattered along the Red River in Marshall, Polk, Norman, and Clay Counties but is most extensive in six townships near the beet sugar plant at East Grand Forks, in Polk County.

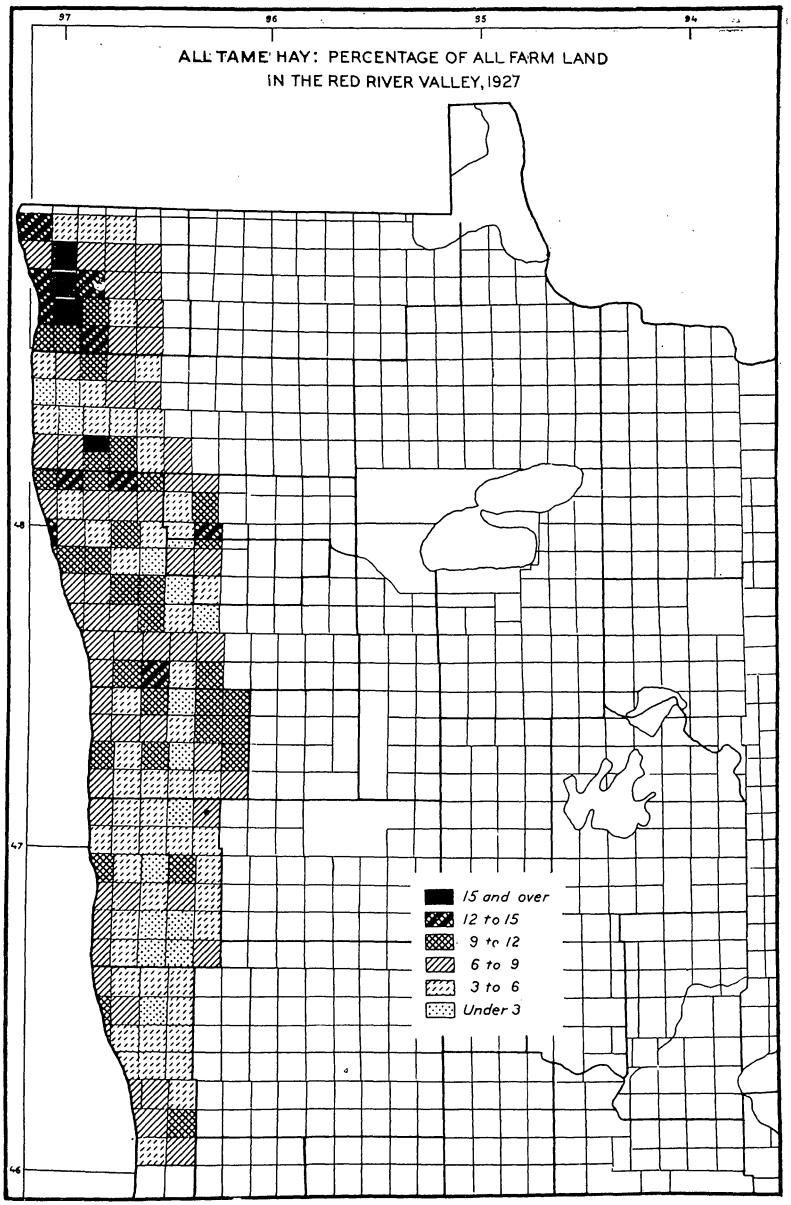

Fig. 17. Percentage of All Farm Land in the Red River Valley in Tame Hay, 1927, by Townships

Alfalfa is the most important hay crop, and is grown on all soils except alkali, peat, or very wet soils.

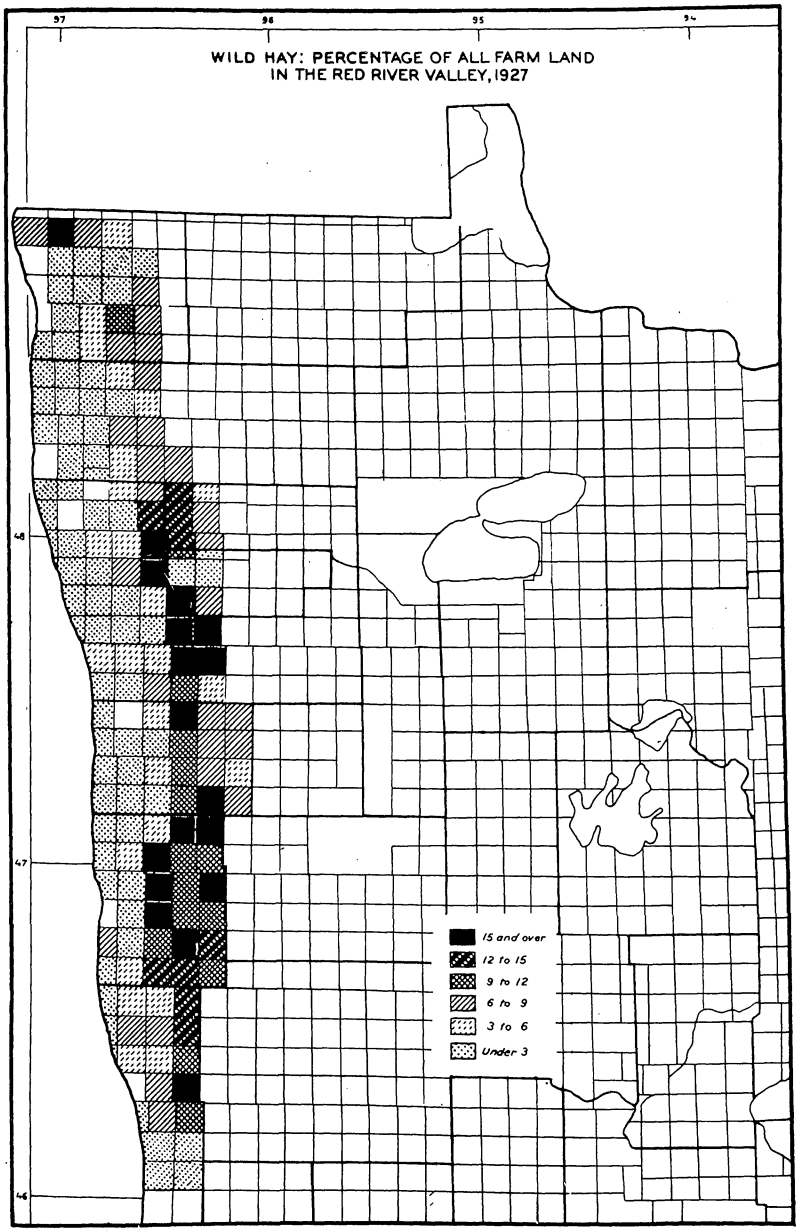

Fig. 18. Percentage of All Farm Land in the Red River Valley in Wild Hay, 1927, by Townships

Wild hay is an important crop on the sandy soils and on the extensive poorly-drained areas.

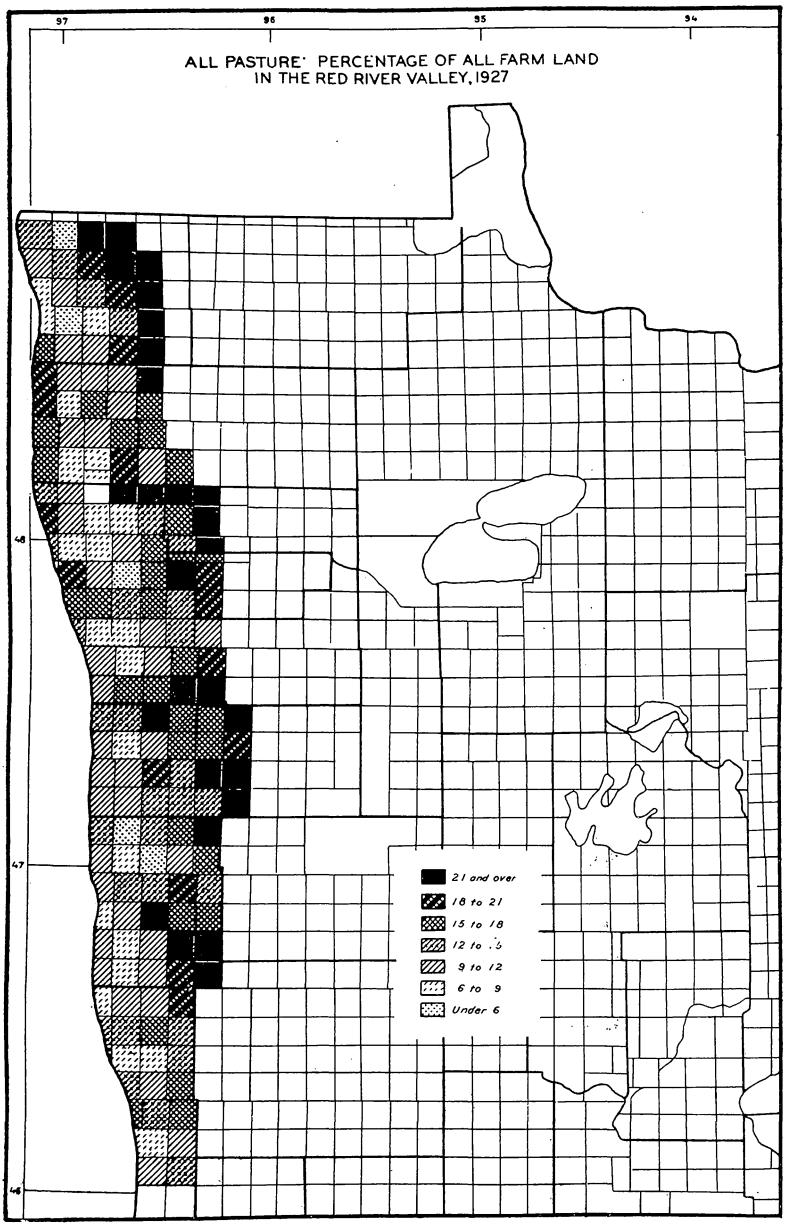

Fig. 19. Percentage of All Farm Land in the Red River Valley in Pasture, 1927, by Townships

Rough topography or an encumbrance of stones or brush are responsible for the relatively large acreage of pasture along the eastern border of the valley.

Closer study of Figures 7 and 8 showing second and third choices and Figures 9 to 20 inclusive, which show the percentage of all farm land in each crop in 1927, by townships, reveals the location of intensive production of the minor crops. Potatoes are important in Clay County; in a small area along the river in Polk County; and, to a lesser degree, in Norman County, where the rich clay soils have just the right amount of sand (see Fig. 14). Flax is important on old land cleaned of weeds by the use of inter-tilled crops in the rotation and in areas still having new land to break each year (see Fig. 12). Corn occupies either second or third place in six townships in Wilkin County, but declines in importance toward the north because of the limitations of climate and, except in a group of townships along the Red Lake River, occupies less than 3 per cent of the farm area in the northern half of the Valley (see Fig. 13). Sugar beet growing is scattered along the river in Marshall, Polk, Norman, and Clay Counties but is most extensive in six townships near the beet sugar plant at East Grand Forks, in Polk County. The acreage did not exceed 4.1 per cent of the farm area in any township in 1927, however (see Fig. 16). Rye is an important crop on the light sandy soils (see Fig. 15). Wild hay, is important on the sandy soils and on the extensive poorly drained areas (see Fig. 18). Tame hay is a major crop, principally in Kittson County and along the eastern border of the Valley. It also ranks first in acreage in some townships in other parts of the Valley (see Fig. 17). Alfalfa is the most important hay crop and is grown on all except alkali, peat, or very wet soils. An additional use of land, which is part of the cropping system, is summer fallow. Figures are not available to show the extent of summer fallow by townships. In general, the amount increases from south to north. In 1925 summer fallow was practiced on 4.4 per cent of the farm area in Wilkin County, 7.2 per cent in Polk County, and 13.6 per cent in Kittson County, according to the Federal Census.

The relative importance of different crops on the farms included in the detailed study in Polk County is shown in Table 5. Wheat was the principal crop on these farms, occupying 16.8 per cent of the total farm acreage. Oats ranked second in importance, on an acreage basis, and pasture as the third most important. Barley, flax, and tame hay, including alfalfa, follow in the order named, each occupying about 10 per cent of the average farm. Corn, potatoes, wild hay, and summer fallow each used about 5 per cent of the farm area. Sugar beets occupied less than 2 per cent of the average farm, but were grown in acreages ranging from 17 to 84 acres on the farms growing beets.

Table 5

Distribution of Crop Acreage on Farms Included in Study in Polk County*

Crop	Acreage†	No. farms growing the crop	Acreage on farms growing the crop			Per cent of total crop acreage
			Average	Maximum	Minimum	
Wheat	3,722	56	66	196	6	17.2
Oats	3,270	57	57	219	12	15.1
Barley	2,377	54	44	153	7	11.0
Flax	2,285	33	69	291	2	10.5
Alfalfa	1,234	50	25	182	2	5.7
Corn	1,212	54	22	63	5	5.6
Wild hay	1,186	38	31	162	1	5.5
Tame hay	932	43	22	95	1	4.3
Potatoes	817	56	15	147	1	3.8
Summer fallow	942	30	31	110	2	4.4
Sugar beets	381	14	27	84	17	1.8
Miscellaneous crops	276	28	10	49	1	1.3
Pasture	2,999	57	52	158	5	13.8

* Records were obtained from 12 farms for the three years 1926-28, from 2 for two years, and from 18 for one year—a total of 58 farm-record years.

† Acreage for 58 farm-record years, 1926-28, inclusive.

No definite rotation was practiced. The sequence of crops was irregular, as shown in Table 6, which gives the percentage of the acreage of specified crops occupied by each of the different preceding crops. Wheat followed all the different crops commonly grown in about the same proportion that each crop occupied farm land. It followed itself, therefore, or another small grain on 49 per cent of the acreage grown. Oats followed itself or another small grain on 72 per cent of the acreage grown. Fifty-five per cent of the barley grown followed a previous crop of either barley, wheat, oats, or flax. Barley was the principal crop seeded after corn. Flax most frequently followed pasture, hay, or idle land. Potatoes, for the most part, followed a small grain or a previous crop of potatoes. Sugar beets require clean land and thus followed either summer fallow, potatoes, pasture, or a previous crop of beets on 80 per cent of the acreage grown. Corn followed spring grains, especially flax.

Table 6

Percentage of Total Acreage of Specified Crops Occupied by Different Preceding Crops on Farms Included in Study in Polk County, 1926-28

Preceding crop	Crop							
	Wheat	Oats	Barley	Flax	Potatoes	Sugar beets	Corn	Alfalfa
	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
Wheat	18	29	15	4	32	1	30	27.2
Oats	12	20	20	3	25	10	21	34.7
Barley	11	11	12	4	8	4	8	31.5
Summer fallow	11	3	6	3	1	27	...	...
Flax	8	12	8	2	5	1	14	3.3
Potatoes	8	7	6	1	15	26	2	...
Pasture	8	3	2	28	2	14	4	...
Sugar beets	6	...	2	...	1	13	...	...
Corn	5	9	20	4	3	1	7	...
Alfalfa	1	...	...	...	1	...	1	...
Tame hay	5	1	3	13	4	...	...	...
Miscellaneous crops	2	2	1	...	2	3	5	...
Idle land	...	...	...	23	...	...	...	...
Unknown	5	3	5	15	1	...	8	3.3
Total	100	100	100	100	100	100	100	100

CROPPING PROBLEMS IN THE RED RIVER VALLEY

The previous section was devoted to an analysis of the conditions, both physical and economic, which have been operating to necessitate changes in the cropping systems. While the cropping systems have undergone a remarkable transition in the last 30 years, especially since the World War, in response to slowly operating physical and economic forces, these forces, or conditions, continue to affect adversely the farming in the area. The elements of this adverse situation constitute major farming problems in the Valley. An appreciation of the importance of these problems and a knowledge of the best methods of overcoming or controlling them is essential to more profitable farming. This section presents a more detailed discussion of these problems in their relation to crop production.

Weed Control

Chief among these problems of outstanding importance in the Valley is the management of the soils so as to eradicate weeds and to keep the land clean. No figures are available as to the extent of the total annual damage caused by weeds, but it varies from none or very slight damage on some farms to an infestation so heavy as to cause the crops to be abandoned on others, depending upon the effectiveness of the control measures used. In late years, sow thistle, Canadian thistle, and quack grass have been the most widespread and the most destructive weeds in the Valley. They thrive in grain fields, especially on damp soils. The

Canadian thistle does not spread so rapidly as the sow thistle, but it is more difficult to eradicate once it has infested a field. Quack grass is found extensively over the entire Valley. It is perhaps not so serious a weed pest as sow thistle, because it does not spread so rapidly, but it is more difficult to clean the land of quack grass than of sow thistle once quack grass has become well established.

The ordinary wild oats are prevalent in grain fields and spread rapidly under conditions of continuous grain cropping. Kinghead, likewise, thrives in grain fields. The presence of the seeds of this weed in the grain lowers the market grade and in this way does more actual damage than its smothering effects in the growing grain. Other weeds of lesser economic importance are the common wild mustard, wild garlic, wild pea or vetch, French weed, wild millet, and wild rose. In some cases these weeds may become a great nuisance; in most instances, however, their injury is slight.

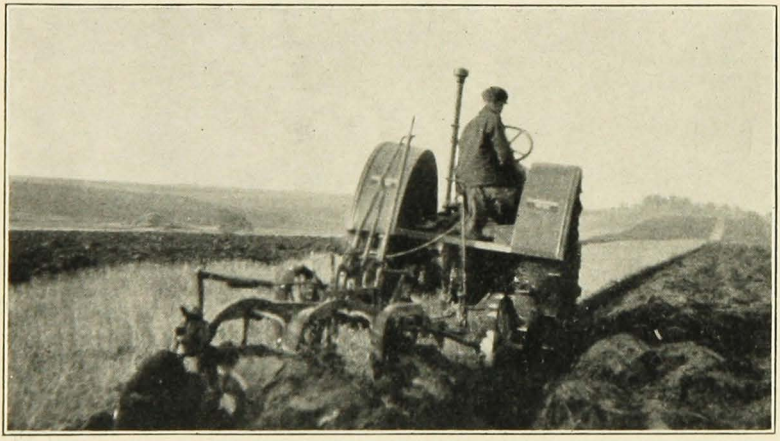

Fig. 20. Fall-plowing a Stubble Field Immediately After the Crop Is Removed

An essential feature of a successful weed-control program is the plowing of the grain fields immediately after the crop is removed from the land.

On badly infested land the first step in eradication or control of weeds is ordinarily a season of summer fallow, using specially adapted tools for cultivation.[4] If the season is not too wet, summer fallow, if properly done, is effective. Continued control is accomplished by seeding legumes in the grain in the spring; plowing the meadow the following year after the first crop, or in July if pastured; keeping the new weed shoots from forming by cultivation until the ground freezes in the fall; and the following year planting to a cultivated crop. It is

[4] For complete instructions on the control and eradication of weeds see Minn. Extension Circulars 25, 26, 28, and 32: "Quack Grass Control," "Perennial Sow Thistle," "Eradicating Canada Thistle," and "Eradicating Perennial Weeds with Chlorates;" also Special Bull. 140, "Eradicating Perennial Weeds in Minnesota."

necessary to rotate a legume and a cultivated crop regularly with the grain crops and to plow the grain fields immediately after the crop is removed from the land. A good stand of alfalfa left on the land for several years usually will eradicate sow thistles. Seeds carried by the wind are always a menace to clean fields, however, and make it necessary to practice control measures continuously.

Disease Control

Paired with the weed problem is the heavy annual toll taken by diseases attacking the various crops, especially wheat. The annual damage of black stem rust to wheat is as high as 30 per cent in seasons favorable to rust development. An estimation of the extent of the losses caused annually to the grain crops in the state as a whole by black stem rust is shown in Table 7. In some years the Valley is not so heavily infested as other parts of the state, but in other years the damage is greatest there. The Bureau of Plant Industry, of the United States Department of Agriculture, has been co-operating with the principal wheat-producing states in the eradication of the common barberry, the winter host of black stem rust, but as yet the lessened amount of damage is uncertain. Early seeding to bring about ripening ahead of weather conditions favorable to rust development and the use of rust-resistant varieties are the most effective methods of combating the disease.[5]

Table 7

Estimated Percentage Reduction in Total Production of Small-Grain Crops in Minnesota Caused by Black Stem Rust, by Years, 1915-29*

Year	Crop			
	Wheat	Oats	Barley	Rye
	per cent	per cent	per cent	per cent
1915	1.4	†	†	†
1916	61.0	†	†	†
1917	0.5	0.5	†	†
1918	0.1	†	†	†
1919	20.0	2.0	5.0	...
1920	30.0	1.0	5.0	0.1
1921	7.0	5.0	3.0	0.1
1922	5.0	2.0	1.0	0.5
1923	15.0	1.0	1.5	0.1
1924	1.0	0.5	0.1	0.1
1925	11.0	0.1	0.5	0.1
1926	5.0	10.0	0.1	...
1927	30.0	15.0	0.1	...
1928	1.8	0.1	0.1	...
1929	15.0	3.0	4.0	...

* Data from Bureau Plant Industry, U. S. Dept. of Agr.
† No report.

[5] Methods of control of cereal diseases in the Red River Valley are described in detail by R S. Dunham, T. M. McCall, and E. R. Clark in Crops and Soils Handbook for Red River Valley, 1929, Northwest Experiment Station, Crookston.

Wheat root rot causes heavy damage on the older wheat lands that have not been farmed with a rotation of crops. This disease can be controlled by crop rotation. Crown rust (leaf rust) on oats is not nearly so serious as black rust, altho a considerable amount appears each year. The smuts of wheat, oats, and barley do serious damage, perhaps to the extent of 10 to 30 per cent annually. Barley stripe is destructive to the barley crop. Control of the smuts and barley stripe is accomplished by proper seed treatment before planting.[6] The only practical control known for crown rust of oats is sowing resistant varieties. Unfortunately, resistant varieties have not been available in commercial quantities until the present time. Damage to flax by wilt can be almost completely avoided by seeding wilt-resistant varieties.[7]

The damage to potatoes by such common diseases as scab, blackleg, mosaic, blight, and fusarium wilt has prevented and is preventing a more rapid expansion of the potato acreage. These diseases can be held in check, however, by careful selection and treatment of seed, by proper cultural practices, and by timely spraying.[8]

Soil Improvement

Records of the annual yields of crops in the Valley previous to 1919 are not available, hence it is impossible to determine the actual trend of yields. However, it is the general opinion of farmers that the continuous growing of spring grains has gradually lowered the yields and that the reduced yields are partly due, in addition to the effects of weeds and diseases, to the gradual depletion of the physical condition and to some extent the fertility of the soil. Results obtained at the Northwest Experiment Station, at Crookston, from different methods of cropping substantiate the belief that continuous cropping reduces yields. As an average for the 17-year period 1910-27, wheat grown continuously at the Station yielded only 14.7 bushels as compared to 24.9 bushels in a 3-year rotation, 24.9 bushels in a 5-year rotation, and 22.8 bushels in a 7-year rotation.[9] This means that 100 acres of land seeded to wheat continuously would eventually produce in total 24 bushels less each year than 60 acres of wheat grown in a 3-year rotation.

The clay soils of the Valley originally contained a liberal supply of partially decayed organic matter which made them friable, but heavy cropping with the spring grains and in many instances careless preparation of the land for seeding, have lowered the humus content on many

[6] For complete instruction on control of smut see Minn. Extension Circ. 24, "Prevent Smuts of Small Grains"; on barley stripe, Minn. Extension Circ. 41, "Control of Barley Stripe."

[7] Minn. Special Bull 128, "Flax Facts."

[8] Minn. Ext. Circ. 22, "Treating Seed Potatoes with Hot Formaldehyde."

[9] Report of Northwest Expt. Sta., Crookston, 1927, p. 23.

farms. These soils have become compact and need loosening by good cultural practices and the addition of humus-forming materials. Getting the soils back into good physical condition is the most important soil problem in the Valley.

Rotation experiments at the Northwest station and the experience of farmers have demonstrated that the turning under of a legume, especially sweet clover, once in each rotation period is very beneficial to the yields of future crops through its loosening effect on the soil. The liberal use of manure, also, is effective, but the benefits are not equal to those from sweet clover. Additional benefits are obtained by following the legume crop and the application of manure with a cultivated crop such as potatoes, sugar beets, or corn, to give the soil an extended period of aeration and thoroly to incorporate the humus material in the soil.

A deficiency in available plant food elements is a problem in some instances on the sandy soils and with certain crops on the heavy soils. Phosphate applied in the form of superphosphate generally has proved profitable with alfalfa, clover, and sugar beets on clay soils. In seasons of normal rainfall, phosphate fertilzers have increased the yields of potatoes from 12 to 50 bushels and sugar beets from one to 2 tons per acre at the Northwest Experiment Station. They have returned a good profit every year when applied to sugar beets. With potatoes, however, the added yields have not covered the added cost except in years of better than average prices.[10]

Complete fertilizers carrying small amounts of nitrogen and potash in addition to phosphate have given additional increases in yields of potatoes on some farms in the sandy areas. A small amount of potash together with phosphate in an 0-16-4 combination has benefited beets in some places in the Valley. In general, however, if second-crop sweet clover is plowed under in preparation of the land for sugar beets and potatoes, or manure is applied, phosphate alone is all that is needed.

Drainage

The drainage problem has never been satisfactorily solved in the Valley. In some respects the problem of drainage is increasing in importance rather than diminishing, notwithstanding the fact that more surface drains are being opened each year. It has never been possible, however, to drain away all the surface water on account of the flatness of the land and the presence of depressions that are lower than ditch levels. As the heavy soils have become more compact with the gradual depletion of the humus they contained as virgin prairie soils, they have become more difficult to drain.

[10] Reported in Crops and Soils Handbook for The Red River Valley, 1920, Northwest Expt. Sta., Crookston.

It is doubtful if tile drainage will prove profitable for some time because of the difficulty and the expense of reaching an outlet and the relatively high cost of draining a field, owing to the closeness with which the tile lines must be laid. In the heavy clay soils, tiles must be laid near the surface in order to draw satisfactorily and the range of a tile line depends upon the depth at which it is laid. Better drainage for the most part, therefore, must be accomplished through more surface drains, the use of deep-rooted crops, and the restoration of the humus content of the soil, making it better adapted to cultivation under conditions of high moisture content.

Adjustment to Progress in Farming Practice

The problem of selecting the most effective materials and equipment for use in the production of crops—a problem common to most agricultural regions that are still experimenting with a type of farming—is important in the Valley.

In this connection the use of the best seed available can not be overemphasized. The Northwest Experiment Station, working in co-operation with the Central station, at St. Paul, has accomplished much in the last few years in developing higher yielding disease-resistant varieties of the grain crops. In Table 8 is shown the average yield of the recommended varieties of different grains in comparison with the average yields of varieties previously considered to be best. Farmers should not hesitate to use new varieties announced by the Northwest Experiment Station as soon as the seed is available in the market. All new varieties are not only thoroly tested at the Station but are further tested in field trials on selected farms in the Valley for three years before they are recommended for general use.

Table 8

Average Yield on Northwest Experiment Station Farm of Recommended Varieties of Specified Grains Compared with Varieties Previously Approved*

Crop	Variety	Period of record	Av. yield per acre, bu.
Wheat	Marquillo†	1925-28	33.5
	Ceres†	1925-28	28.4
	Marquis	1925-28	25.0
Oats	Anthony†	1925-28	60.7
	Gopher	1925-28	45.4
Barley	Trebi†	1923-27	37.8
	Minnesota 184	1923-27	33.9
Flax	Buda†	1928-30	12.7
	Chippewa	1928-30	12.0

* Minn. Agr. Expt. Sta. Bull. 264, "Small Grain Varieties in Minnesota," by H. K. Wilson and A. C. Arny; "Flax Summary Report, 1930," by A. C. Arny, W. E. Haines, and G. H. Robinson.

† Recommended varieties.

Mechanization in the Red River Valley is proceeding at a fairly rapid rate. The general-purpose tractor, which is being generally adopted, is bringing with it a larger use of the combine for harvesting small grains and flax and is occasioning a considerable modification of machinery for handling potatoes and sugar beets, looking toward a greater use of mechanical power and a reduction of man labor used for these crops. This is increasing the capacity of the individual farm worker for the production of the relatively higher income-per-acre crops and at the same time reducing the per-acre charges for materials and the use of equipment.

The data presented in Table 9 show the saving in man labor, horse work, and cash charges for equipment and materials that were obtained on one of the farms studied through the substitution of a combine for the binder-thresher method for harvesting and threshing small grains and flax. In addition to the per-acre saving of 1.4 hours of man labor, 1.75 hours of horse labor, and 12 cents in other charges in favor of the combine, the combine method has the advantage of putting the field in readiness for beginning fall plowing immediately after harvest. Moreover, if harvesting operations are interrupted by wet weather the labor and power forces can be kept busy at fall plowing. This advantage is especially important in relation to weed control. In evaluating this comparison, it should be remembered, however, that the straw was left in the field when the combine was used. Furthermore, the acreage of small grain on this farm was sufficient to use a combine economically. On 160- to 320-acre diversified farms the acreage of crops to be harvested with the combine is too small to afford much advantage.

Table 9

Comparison of Cost per Acre of Harvesting and Threshing by Different Methods on the Same Farm*

Item	Machine used	
	1927	1928, 1929
	10-foot tractor-binder and stationary thresher	10-foot combine and 12-foot windrower
Acres covered	303	326
Man labor (at 40 cents per hour)	$1.30	$0.74
Horse work (at 12 cents per hour)	0.39	0.18
Tractor work, hr.	0.35	0.58
Twine cost	0.27	....
Machine charge	0.21	1.13
Threshing charge	1.00	....
Total cost	$3.52	$2.63

* Adapted from data presented in Table 8, Minn. Agr. Expt. Sta. Bull. 266, "Cost of Combine Harvesting in Minnesota." 1929.

Adjustment to Changing Price Relations

The substantially lower cost of wheat production made possible in extensive areas by recent improvements in the tractor, the combine, and tillage machinery have resulted in a substantial increase in the acreage of spring wheat in the regions west and northwest of the Valley in both the United States and Canada. These lower costs (coupled with increased production in other wheat-producing countries resulting from a combination of influences), have tended to increase the total output, to lower the price at which wheat can be continuously supplied, and to intensify inter-regional competition, thus making changes necessary in the agriculture of the areas in which the more efficient methods are less applicable. Further important developments in this direction are to be expected.

Greatly reduced costs in wheat production have not been experienced in the Red River Valley of Minnesota through the use of machines in large units in large-scale operations. A considerable further development in the use of power machinery and the combine may be expected in the Valley wherever large tracts of land particularly well adapted to wheat are under the control of one operator. Under these conditions, a fairly high degree of specialization in wheat growing in conjunction with other small grains is economically desirable. On the other hand, in other parts of the Valley less favorably adapted to large-scale operations in wheat growing, readjustments in the cropping system limiting the acreage of wheat to the portion of the farm that can be maintained on a high-yielding basis through crop rotation, offers a better solution to the problem of intensified regional competition and lowering prices for wheat.

QUANTITIES OF LABOR AND MATERIALS USED FOR CROP PRODUCTION

A consideration of the readjustments in the cropping system that promise to contribute higher earnings from the entire farm involves the use of information on: (1) the amounts of labor, power, equipment, and materials used in the production of units of the different crops under careful management with conditions ordinarily prevailing; (2) the variations between farms in amounts of these factors used, together with the causes for significant variations; and (3) the seasonal distribution of the demands of each crop for labor and power and the probable number of work days available for each of the crop operations. With these data available, the farmer is in position to forecast the demands upon his resources of changes in his cropping system and the effect on his earnings.

An essential part of the 3-year detailed study of representative farms in Polk County was the collection of information on the basic amounts of labor, power, equipment, and materials used in the production and harvesting of units of the different crops and the time distribution of the use of these elements. The amount of man labor and horse work used on the farms studied for the different operations commonly performed in the production of crops in the Valley are presented in Tables 10 to 46 for each farm for 1927. The year 1927 was selected for presenting data on individual farms because weather conditions were more nearly normal than in either of the other two years (see Table 1 and Fig. 2). Averages of all farms are shown for each of the three years included in the study.

A careful study of the quantities of man labor and horse work used on different farms in the production of any crop reveals that there are variations between farms in the use of these factors. An attempt is made to explain some of the significant variations found, so that a consideration of the causal factors will help the farmer to determine what quantities he should use with the conditions on his farm.

Following the analysis of the variations in amounts of labor and materials used in the performance of the different operations, quantities are given that represent what may reasonably be expected to be used under careful management with conditions ordinarily prevailing. They represent, approximately, the accomplishments of farmers who were 25 per cent above the average in the scale of efficiency, as measured by low labor expenditure for a given operation, and are suggested as standards with which farmers in the area may compare their own accomplishments and check the effectiveness with which they are utilizing their own labor and power resources. These standards serve, also, as basic quantities, when properly adjusted to conditions at the particular farm, for use in planning readjustments in the cropping systems.

In computing these standards, an allowance has been made for time used going to and from fields, and all ordinary interference necessarily incident to field work, such as adjusting and repairing machinery in the field, rest periods, and minor weather disturbances.

Wheat

Usual Practices in Wheat Production

The Valley is a spring wheat area and the acreage of winter wheat is relatively insignificant. The wheat grown on the farms studied was all spring wheat. As it is the first crop seeded in the spring, as much of the land is fall plowed as time and the weather will permit. Where wheat follows summer fallow, sugar beets, or potatoes the land usually is not plowed unless very weedy. On the farms studied, approxi-

mately 20 per cent of the land that had been in these three crops the previous year, was plowed for wheat. Only 4 per cent of all land plowed for wheat was plowed in the spring. In addition to plowing, the land may be disked, spring-tooth harrowed, or dragged with an ordinary spike-tooth harrow before seeding. Only 17 per cent of the land for wheat was disked and less than one-fourth of this was covered more than once. Approximately 41 per cent of the land was worked with a spring-tooth harrow. Generally speaking, the land that was disked was not worked with a spring-tooth harrow. About one-third of the land was harrowed once before seeding with an ordinary spike-tooth harrow and an additional two-fifths was harrowed twice. Wheat, as well as all other small grains, was drilled. Approximately 70 per cent of the wheat was harrowed after seeding. In addition, a few farmers rolled or cultipacked their wheat land. More of this was done the last year than in the preceding two years. The general practice has been to cut and shock the grain and thresh from the shock. With the advent of the combined harvester-thresher, it is to be expected that more of the grain will be threshed standing or from the windrow. A small amount of combine harvesting was done on three of the farms studied in 1928.

Variations in Labor Expenditures on Wheat

The hours of man labor, horse work, and tractor work used per acre in performing each operation on each of the farms studied and the average for each of the three years are presented in Tables 8 and 9. These data show a variation in the total amount of man labor used per acre from 4.7 to 11.5 man hours. Likewise there is a similarly wide variation in the amount of horse and tractor work used. There are several causes for these variations.

Table 10

Man Labor Used per Acre by Operations on Wheat, 1927

Farm No.	Acres per farm	Yield, bu.	Fall plowing		Disking		Spring-tooth harrowing		Harrowing		Seeding, hours	Cutting, hours	Shocking, hours	Threshing, hours	Total man hours
			Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over					
026	70	10.9	....	....	0.44	0.53	0.62	1.00	....	....	0.55	0.78	0.71	1.63	4.73
161	133	9.6	1.91	1.00	0.21	0.40	....	....	0.41	2.04	0.61	0.65	0.70	1.46	5.95
051	39	12.7	2.00	1.00	0.48	0.59	....	....	0.60	1.41	0.60	0.73	0.61	1.06	6.08
232	69	17.5	0.51	1.00	....	....	0.36	1.00	0.18	0.45	0.60	0.43	1.47	2.84	6.39
025	36	11.3	1.35	0.57	0.76	1.00	....	....	0.45	1.43	0.65	0.62	0.76	1.85	6.44
031*	6	20.2	....	....	0.81	2.00	....	....	....	....	0.60	1.09	1.73	3.23	7.46
023	96	16.1	1.23	0.40	0.11	0.15	0.79	0.91	0.58	2.17	0.53	1.06	1.07	2.17	7.54
201	47	11.7	2.86	1.00	....	....	0.38	1.00	0.87	3.00	0.42	0.73	0.95	1.46	7.67
022	26	9.8	2.33	0.79	0.53	1.58	1.06	1.21	0.12	0.79	0.49	0.68	0.91	1.80	7.92
231	115	12.4	1.20	0.79	0.08	0.25	0.63	1.09	0.34	1.35	0.56	0.93	1.74	2.45	7.93
221	29	11.2	1.76†	1.00	0.56	0.76	....	....	0.56	2.52	0.46	1.06	1.04	2.62	8.06
073	58	20.2	1.39	0.70	0.43	0.61	0.39	0.70	0.19	1.00	0.59	0.49	1.18	3.57	8.23
233	40	14.5	0.97	1.00	....	....	0.40	1.00	0.21	0.64	0.57	1.55	1.06	3.50	8.26
021	12	6.7	1.34	1.00	1.66	1.00	0.69	1.00	0.32	1.00	0.52	0.67	1.06	3.02‡	9.28
082	69	16.1	2.21	0.77	0.31	0.33	....	....	1.31	3.00	0.68	0.78	2.32	2.69	10.30
032*	16	21.8	1.99	0.32	....	....	1.52	2.00	....	....	1.09	1.13	1.61	4.16	11.50
Average															
1927	60	12.9	1.50	0.79	0.40	0.52	0.38	0.64	0.44	1.49	0.56	0.80	1.11	2.24	7.43
1926	83	12.0	1.66	0.69	0.04	0.11	0.17	0.33	0.58	1.89	0.58	0.80	0.98	2.15	6.96
1928	67	19.5	1.35	0.77	0.14	0.27	0.25	0.48	0.43	1.73	0.56	0.73	1.12	2.13	6.71

* Omitted from the average because not representative.

† Includes 7 acres spring plowing.

‡ Includes stacking and threshing from the stack. This farm was omitted from the average for threshing.

Table 11

Horse and Tractor Work Used per Acre by Operations on Wheat, 1927

Farm No.	Acres per farm	Yield, bu.	Fall plowing			Disking			Spring-tooth harrowing			Harrowing			Seeding		Cutting		Threshing	Total	
			Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Horse hours	Tractor hours	Horse hours	Horse hours	Tractor hours
026	70	10.9	....	....	....	1.76	....	0.53	2.89	....	1.00	....	....	....	2.11	....	3.14	....	3.31	13.21	....
161	133	9.6	9.01	....	1.00	0.84	....	0.40	....	....	....	1.63	....	2.04	2.08	....	2.59	....	2.83	18.98	....
051	39	12.7	2.80	1.06	1.00	....	0.48	0.59	....	....	....	2.39	....	1.41	1.41	....	2.91	....	1.87	11.38	1.54
232	69	17.5	....	0.51	1.00	....	....	....	0.47	0.24	1.00	0.58	....	0.45	2.30	....	....	0.43	4.69	8.04	1.18
025	36	11.3	6.45	....	0.57	3.02	....	1.00	....	....	....	1.79	....	1.43	2.55	....	2.47	....	3.08	19.36	....
031*	6	20.2	....	....	....	3.23	....	2.00	....	....	....	....	....	....	2.42	....	4.35	....	6.45	16.45	....
023	96	16.1	6.31	....	0.40	0.45	....	0.15	3.10	....	0.91	2.31	....	2.17	2.14	....	4.16	....	4.30	22.77	....
201	47	11.7	14.67	....	1.00	....	....	....	1.99	....	1.00	4.63	....	3.00	1.70	....	2.93	....	2.92	28.84	....
022	26	9.8	....	2.33	0.79	....	0.53	1.58	4.40	....	1.21	....	0.12	0.79	1.97	....	2.73	....	3.15	12.25	2.98
231	115	12.4	3.67	0.37	0.79	0.34	....	0.25	2.38	0.04	1.09	1.35	....	1.35	2.23	....	3.73	....	3.85	17.56	0.41
221	29	11.2	8.80	....	1.00	2.26	....	0.76	....	....	....	2.26	....	2.52	1.85	....	4.24	....	5.23	24.64	....
073	58	20.2	6.96	....	0.70	1.91	....	0.61	2.35	....	0.70	0.77	....	1.00	2.36	....	1.95	....	5.89	22.19	....
233	40	14.5	....	0.97	1.00	....	....	....	0.55	0.26	1.00	0.85	....	0.64	2.30	....	....	0.54	5.59	9.29	1.77
021	12	6.7	....	1.34	1.00	6.47	....	1.00	2.67	....	1.00	1.29	....	1.00	2.07	....	2.67	....	4.31†	19.48	1.34
082	69	16.1	7.77	....	0.77	1.23	....	0.33	....	....	....	3.50	....	3.00	2.51	....	3.09	....	5.00	23.10	....
032*	16	21.8	5.63	....	0.32	....	....	....	6.05	....	2.00	....	....	....	2.17	....	4.53	....	8.31	26.69	....
Average																					
1927	60	12.9	4.75	0.47	0.79	1.31	0.07	0.52	1.49	0.04	0.64	1.67	0.01	1.49	2.11	....	2.62	0.07	3.98	17.93	0.66
1926	83	12.0	7.51	0.03	0.69	0.11	....	0.11	0.55	0.02	0.33	1.66	0.01	1.89	2.25	....	2.38	0.08	3.88	18.34	0.14
1928	67	19.5	3.97	0.53	0.77	0.54	0.01	0.27	0.62	0.10	0.48	1.57	0.01	1.73	1.96	0.05	2.27	0.12	3.54	14.47	0.83

* Omitted from the average because not representative.

† Hours include stacking and threshing from the stack. This farm was omitted from the average for threshing.

Variations in cropping practices.—One very significant cause of variation in the total labor expenditure is that in the number of operations performed in the process of seedbed preparation, owing largely to differences in the condition of the soil and in weed infestation. Obviously, where it is possible to substitute disking or spring-tooth harrowing for plowing or to eliminate one or more operations, the time is considerably reduced. Perhaps there is a tendency on the part of some farmers to work the land more than is essential and on the part of others to work it less than is desirable. Besides the differences in cultural practices, several factors influence the efficiency in the particular operation.

Size, shape, and location of fields.—A great proportion of time is spent in turning and in working the ends or corners on small or irregularly shaped fields. This is illustrated by the labor spent cutting wheat. All the five farms with the highest labor expenditure for cutting had relatively small fields. The amount of man labor used for cutting on Farm 233 was further increased by the tractor and two binders used. One man was used to operate the tractor in addition to the two men operating the binders. On Farm 032, the fields were both small and irregular in shape. Obviously, the farther the field is from the buildings the more time is spent in going to and from the fields. It is sometimes possible to reduce the disadvantage arising from having small fields by working adjoining fields as one. Fences or ditches eliminate this possibility.

Size of power units.—Another factor influencing the efficiency of man labor used in crop operations was the size of the power unit. On both Farms 082 and 032, the power unit for plowing was largely a three-horse one-bottom plow outfit. Generally speaking, with a larger outfit proportionately less of the operator's time is occupied in turning at the ends and in going to and from the field. The saving is primarily in man labor, not in horse work.

Yield.—The yield will affect to some extent the time necessary to shock and thresh the crop. The farms in 1927 having a yield of less than 13 bushels per acre averaged approximately a third less labor per acre than those having a yield of more than 13 bushels. The amount of labor used per bushel, however, works in the opposite direction. With higher yields, less time is required per bushel. The yield has little effect on the time required for the other operations except insofar as a higher yield is the result of a little better job of seedbed preparation.

Quality of labor.—The quality of the labor may affect the time expended. If a large amount of the labor is done by members of the family, more time may be consumed than if it is done by hired help. Lack of experience, insufficient physical strength, hesitation on

the part of parents to require relatively as much from their children as from hired help, and the occasional lack of adjustment between the available labor supply and the amount of work to be done, a result of the gradual growing up of the children, are some of the main reasons for differences in efficiency.

Management.—Variations in labor expenditures may also arise as a result of differences in management. Planning the work so as to have the right tools, power units, and man labor ready at the right time and place to perform the desired operations at the most opportune time tends to increase the efficiency of labor.

Materials Used in Wheat Production

Approximately 60 per cent of the wheat acreage on the farms studied was devoted to raising bread wheat and 40 per cent to raising durum, or macaroni, wheat. Three-fourths of the acreage of bread wheat was seeded to Marquis and practically the entire acreage of durum was seeded to Mindum. The amount seeded was uniform, varying little from 1½ bushels per acre. When the wheat was cut with a binder, the amount of twine used averaged between 2¼ and 2½ pounds per acre. Variations in the amount used were chiefly the result of differences in the yield of straw. Twine is not used when harvesting is done with a combine. Custom threshing was hired by the bushel or by the hour. The hour basis was used more frequently in years of low yields. On the farms studied, the most common rate for threshing wheat was 6 cents per bushel. The hour rate varied from $4.50 to $8.00 per hour, depending upon the size of the machine and the number of spike pitchers or other helpers furnished with it.

Standards for Wheat Production

Successful planning of a cropping program involves an estimate of the amount of time necessary to perform the desired operations on a given acreage. Standards of performance that may be attained under reasonably good management, with both horse- and tractor-drawn implements, are presented in Tables 12 to 15.

Table 12

Standards per Acre for Seedbed Preparation and Seeding Wheat with Horse-Drawn Implements

Operation	Implement	Man hours	Horse hours
Plowing	5 horses and 28 in. gang	2.00	10.00
Disking	4 " " 8-ft. single disk	0.45	1.80
Spring-tooth harrowing	4 " " 10-ft. harrow	0.50	2.00
Harrowing	4 " " 22-ft. "	0.20	0.80
Seeding	4 " " 10-ft. drill	0.50	2.00

Table 13

Standards per Acre for Seedbed Preparation and Wheat Seeding with Tractor-Drawn Implements*

Operation	Implement	2-Plow		3-Plow	
		Man hours	Tractor hours	Man hours	Tractor hours
Plowing	14-in. bottoms	1.40	1.40	1.00	1.00
Disking	8-ft. tandem disk	0.42	0.42	0.33	0.33
	10-ft. " "	0.36	0.36	0.29	0.29
Spring-tooth harrowing	8-ft. harrow	0.48	0.48	....	....
	10-ft. "	0.38	0.38	0.34	0.34
	12-ft. "	....	....	0.29	0.29
Harrowing	20-ft. "	0.16	0.16	0.15	0.15
	26-ft. "	0.13	0.13	0.11	0.11
Drilling	10-ft. drill	0.36	0.36	....	....
	14-ft. "	....	....	0.25	0.25

* Adapted from Table 14, Minn. Agr. Expt. Sta. Bull. 280, "The Farm Tractor in Minnesota." A. J. Schwantes and G. A. Pond.

Table 14

Standards per Acre for Binder Harvesting and Shock-Threshing of Wheat

Operation	Implement	Man hours	Horse hours	Tractor hours	
				2-plow	3-plow
Harvesting	4 horses— 8-ft. binder	0.70	2.80	....	....
	Tractor— 8-ft. "	*	....	0.42	0.40
	" 10-ft. "	*	....	0.33	0.32
	" 2-8 ft. "	0.72	....	....	0.24
Shocking		0.90	....	....	....
Threshing		2.10	3.70	....	....

* Recommended man hours same as the corresponding tractor hours.

Table 15

Standards per Acre for Harvesting Wheat with Combine Harvester*

Operation	Implement	Man hours	Horse hours	Tractor hours	
				2-plow	3-plow
Windrowing	12-ft. windrower (horse drawn)	0.37	1.37	....	....
	12-ft. windrower	0.26	....	0.26	....
	16-ft. "	0.20	....	....	0.20
Threshing†	8-ft. combine	1.08	1.20	....	0.48
	10-ft. "	1.23	1.20	0.40	....
	12-ft. "	1.29	1.20	....	0.32
	16-ft. "	1.06	1.20	....	0.25

* Based on Table V, p. 12, Minn. Agr. Expt. Sta. Bull. 266, "Cost of Combine Harvesting in Minnesota," G. A. Pond and L. B. Bassett.

† Man and horse hours include hauling grain.

The standards given are for the power units most commonly used. The Northwest Experiment Station, at Crookston, recommends seeding 75 to 90 pounds of common wheat and 105 of amber durum per acre. This assumes clean seed of high germination. With low germination, more is needed per acre in order to obtain as good a stand. When the grain is cut and shocked, 2½ pounds of twine per acre should be sufficient for a good average yield.

Distribution of Labor on Wheat

The beginning and ending dates of the periods during which the operations on the wheat crop are commonly performed, together with the number of days usually available, are given in Table 16. These dates vary from year to year, depending on the weather and the advancement of the season, but the general relationships will remain approximately the same. In some cases the operations may be started earlier or finished later than indicated here, but these dates will serve as a safe basis for planning the farm organization. In determining the number of work days available, allowance was made for Sundays, holidays, and the probable days on which rain might interfere with crop operations.

Fig. 21. A Wheat Field in the Red River Valley

Yields such as indicated in the picture enable wheat to maintain its rank as a leading crop.

Table 16
Usual Dates and Work Days Available for Performing Different Field Operations on Wheat

Operation	Usual dates	Work days available
Seedbed preparation	Mar. 30 to May 1	20
Seeding	Apr. 1 to May 2	21
Cutting	July 25 to Aug. 22	16
Threshing	Aug. 16 to Sept. 20	28

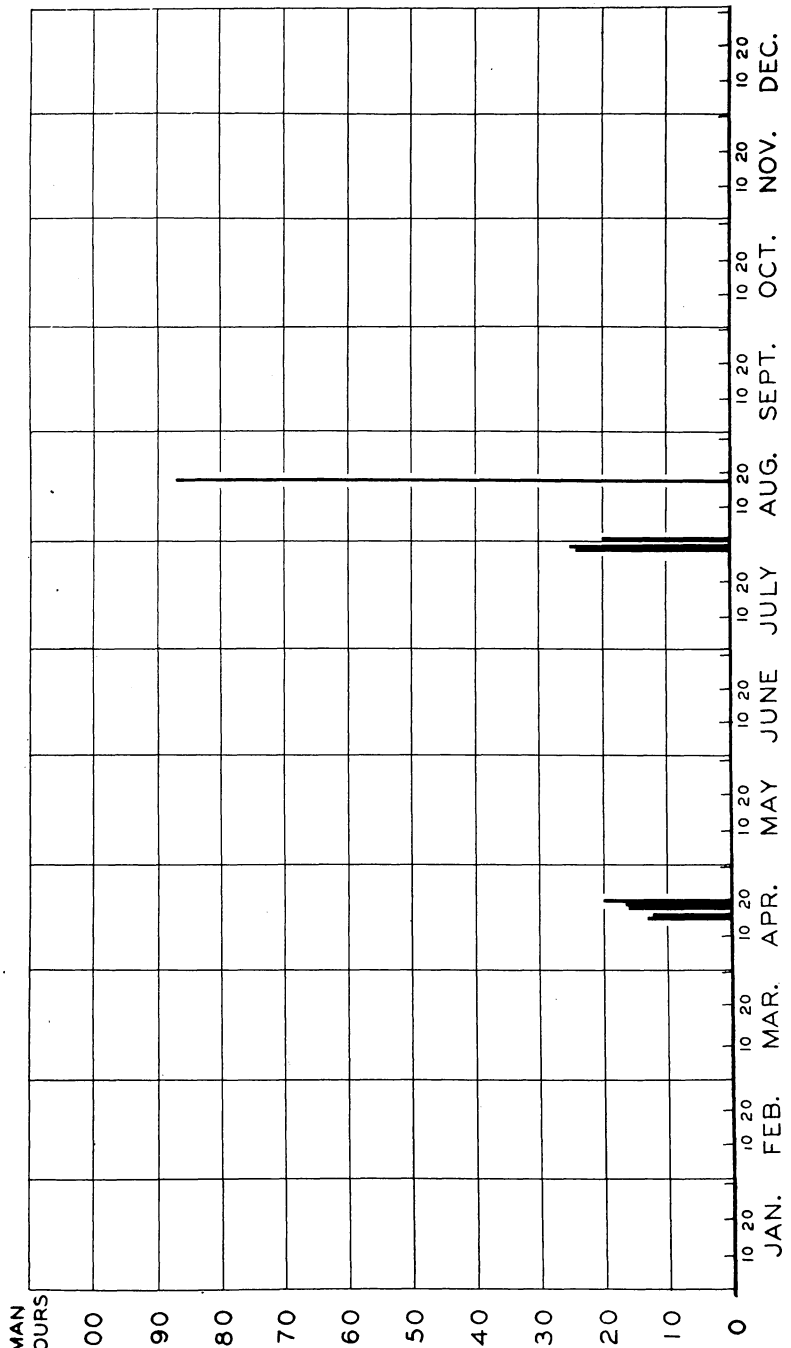

Fig. 22. Daily Distribution of Man Labor on a 39-Acre Field of Wheat

Wheat is the first crop to be seeded in the spring and is usually seeded on fall-plowed or summer-fallowed land.

The daily distribution of man labor on a 39-acre field of wheat is shown in Figure 23. The labor on wheat is concentrated in one week, about the 18th of April, three days harvesting in the latter part of July, and one day threshing in the middle of August. Fall plowing may be done any time after harvest and before the ground freezes in the fall. On this farm the fall plowing was done in the period from August 5 to October 2. This distribution is typical of the region. With a larger acreage of wheat, the labor might be extended over a longer time.

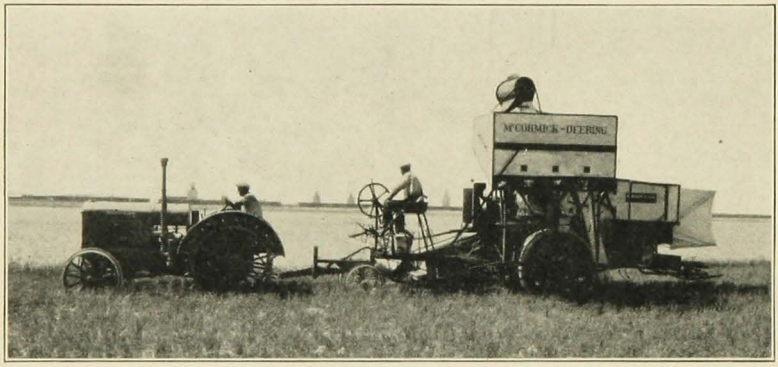

Fig. 23. Harvesting With a Combine

Combining is rapidly replacing on medium- and large-sized farms the binder-shock-threshing method of harvesting small grain in the Valley.

Oats

Usual Practices in Oats Production

In preparation of the seedbed for oats, 85 per cent of the land was plowed. Fall plowing was preferred, but it was not always possible to plow all the land in the fall. In the three years, the proportion of the plowing done in the fall varied from 43 per cent in 1926 to 98 per cent in 1927. The average proportion for the three years was 74 per cent. Approximately 20 per cent of the land was disked once and 7 per cent twice. Twenty-two per cent of the land was spring-tooth harrowed once and another 6 per cent either two or three times. Thirty per cent of the land was harrowed once before seeding, 41 per cent was harrowed twice, and 2 per cent either three or four times. Sixty-seven per cent of the land was harrowed once after seeding and 2 per cent was covered twice. In addition, a few farmers did some rolling or pulverizing. As with wheat, most of the oats was cut with an 8-foot binder drawn by 4 horses and was threshed from the shock. In 1928 two farmers used a combine harvester.

Table 17
Man Labor Used per Acre by Operations on Oats, 1927

Farm No.	Acres per farm	Yield, bu.	Plowing		Disking		Spring-tooth harrowing		Harrowing		Seeding, hours	Cutting, hours	Shocking, hours	Threshing, hours	Total man hours
			Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over					
026	82	16.3	1.32	0.63	0.27	0.43	0.92	1.00	....	....	0.60	0.75	0.54	1.20	5.60
231	57	9.2	1.57	0.91	....	....	0.82	1.09	0.26	1.09	.52	0.69	0.73	1.13	5.72
022	30	12.5	1.63	1.00	.68	1.28	1.43	2.00	....	....	.49	0.68	0.61	0.63	6.15
072	106	26.7	1.40	0.70	.35	0.60	0.33	0.51	0.16	0.68	.59	0.64	0.73	2.17	6.37
201	51	22.7	2.02	1.00	....	....	0.08	0.33	0.80	3.00	.62	0.66	0.59	1.64	6.41
021	13	16.2	1.28	1.00	.31	0.47	1.05	1.00	0.37	1.00	.50	0.68	1.12	1.12*	6.43
024	34	42.6	1.00	1.00	.31	0.77	0.13	0.23	0.10	1.00	.64	0.86	0.83	2.70	6.57
025	40	19.3	2.11	0.90	.28	0.20	0.59	0.91	0.26	1.00	.53	0.71	0.61	1.50	6.59
232	50	25.3	1.04	1.00	....	....	0.75	1.00	0.24	1.00	.75	0.38	0.95	2.69	6.80
051	32	26.4	2.00	1.02	.82	1.00	....	....	0.56	1.00	.61	0.66	0.69	1.80	7.14
233	65	18.6	1.56	1.00	....	....	0.69	2.19	0.32	1.00	.88	1.11	0.94	1.66	7.16
221	12	9.3	2.01	1.00	.77	1.00	....	....	0.60	2.00	.94	0.86	0.77	1.45	7.40
032†	12	35.7	....	1.00	.29	0.37	....	....	1.44	1.69	.82	1.15	0.99	2.88	7.57
023	65	24.1	1.89	0.84	.27	0.17	0.94	1.13	0.57	1.82	.55	0.77	0.85	1.95	7.79
161	115	36.5	2.43	1.00	.60	1.08	....	....	0.49	2.11	.61	0.77	0.84	2.12	7.86
081	26	33.1	1.26	0.55	.19	0.27	1.40	1.47	0.50	1.42	.44	0.81	1.24	3.07	8.91
031†	33	42.7	1.13	0.33	.84	1.10	0.16	0.43	1.03	1.26	.68	1.03	1.99	3.32	10.18
082	38	36.2	2.83	1.00	....	....	0.26	0.23	1.23	3.00	.68	0.81	2.06	2.74	10.61
Average															
1927	51	23.4	1.71	0.91	.30	0.45	0.59	0.82	0.40	1.32	.62	0.74	0.88	1.85	7.09
1926	68	28.2	1.69	0.88	.07	0.12	0.12	0.20	0.42	2.04	.63	0.81	1.25	2.03	7.02
1928	50	43.2	1.35	0.76	0.18	0.44	0.16	0.36	0.18	2.02	0.56	0.73	1.02	2.10	6.58

* Omitted from the average for threshing because it includes stacking.

† Omitted from the average because not representative.

Table 18
Horse and Tractor Work Used per Acre by Operations on Oats, 1927

Farm No.	Acres per farm	Yield, bu.	Plowing			Disking			Spring-tooth harrowing			Harrowing			Seeding	Cutting		Threshing	Total	
			Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Horse hours	Tractor hours	Horse hours	Horse hours	Tractor hours
026	82	16.3	7.52	....	0.63	1.09	....	0.43	3.72	....	1.00	....	....	....	2.39	3.01	....	2.39	20.12	....
231	57	9.2	0.65	1.09	0.91	....	....	....	2.75	0.13	1.09	1.06	....	1.09	1.98	2.75	....	1.82	11.01	1.22
022	30	12.5	....	1.63	1.00	....	0.68	1.28	5.74	....	2.00	....	....	....	1.96	2.70	....	1.00	11.40	2.31
072	106	26.7	6.98	....	0.70	1.38	....	0.60	1.99	....	0.51	0.62	....	0.68	2.29	2.44	....	3.48	19.18	....
201	51	22.7	9.92	....	1.00	....	....	....	0.31	....	0.33	4.80	....	3.00	1.99	2.66	....	3.27	22.95	....
021	13	16.2	....	1.28	1.00	1.24	....	0.47	....	1.05	1.00	1.47	....	1.00	2.02	2.71	....	0.78*	8.22	2.33
024	34	42.6	....	1.00	1.00	....	0.31	0.77	....	0.13	0.23	....	0.10	1.00	2.51	....	0.43	2.86	5.37	1.97
025	40	19.3	10.14	....	0.90	1.10	....	0.20	1.15	0.31	0.91	1.05	....	1.00	2.13	2.85	....	1.94	20.36	0.31
232	50	25.3	....	1.04	1.00	....	....	....	2.47	0.13	1.00	0.96	....	1.00	2.55	....	0.38	4.91	10.89	1.55
051	32	26.4	2.90	1.00	1.02	3.28	....	1.00	....	....	....	2.24	....	1.00	2.31	2.65	....	3.03	16.41	1.00
233	65	18.6	....	1.56	1.00	....	....	....	....	0.69	2.19	1.29	....	1.00	3.27	....	0.38	2.90	7.46	2.63
221	12	9.3	10.05	....	1.00	3.08	....	1.00	....	....	....	2.40	....	2.00	3.76	3.42	....	2.91	25.62	....
032†	12	35.7	....	....	....	1.15	.. .	0.37	....	....	....	4.32	....	1.69	3.29	4.61	....	5.76	19.13	....
023	65	24.1	9.43	....	0.84	0.49	....	0.17	3.77	....	1.13	2.27	....	1.82	2.20	3.08	....	3.73	24.97	....
161	115	36.5	11.84	....	1.00	2.42	....	1.08	....	....	....	1.94	....	2.11	2.38	3.06	....	4.23	25.87	....
081	26	33.1	0.78	1.01	0.55	0.74	....	0.27	5.59	....	1.47	1.99	....	1.42	1.76	3.24	....	5.72	19.82	1.01
031†	33	42.7	4.79	....	0.33	3.36	....	1.10	0.64	....	0.43	2.65	....	1.26	2.72	4.12	....	6.48	24.76	....
082	38	36.2	9.87	....	1.00	....	....	....	1.02	....	0.23	3.36	....	3.00	2.52	3.26	....	4.78	24.81	....
Average																				
1927	51	23.4	5.01	0.60	0.91	0.93	0.06	0.45	1.78	0.15	0.82	1.59	0.01	1.32	2.38	2.36	0.07	3.11	17.16	0.89
1926	68	28.2	7.73	0.17	0.88	0.26	....	0.12	0.39	....	0.20	1.64	....	2.04	2.49	2.71	0.07	3.52	18.74	0.24
1928	50	43.2	4.51	0.43	0.76	0.58	0.04	0.44	0.44	0.06	0.36	1.69	0.03	2.02	2.15	2.38	0.09	3.50	15.25	0.65

* Not included in the average for threshing because it includes stacking.

† Omitted from the average because not representative.

Variations in Labor Expenditures on Oats

The expenditures of man labor, horse work, and tractor work on each of the farms studied in 1927 and averages for 1926, 1927, and 1928 are given in Tables 17 and 18. The average amount of man labor used on oats was practically the same as for wheat. It varied from 5 to 10.6 hours per acre. In general, the factors that were responsible for the variations in the expenditure of man labor on oats were the same as those discussed under wheat, namely, differences in (1) seedbed preparation, (2) size, shape, and location of fields, (3) size of power units, (4) yield, (5) quality of labor, and (6) management.

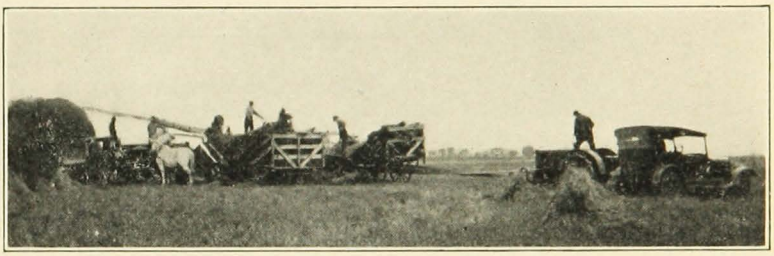

Fig. 24. A Typical Threshing Scene in the Valley

Up to 1927 practically all small grain in the Red River Valley was threshed from the shock with the ordinary stationary grain separator. This is still the prevailing method of threshing on most farms, altho the combine harvester is beginning to displace it on the larger farms.

Materials Used for Oats

The varieties of oats most generally grown were Gopher, White Russian, and Green Russian. The amount of seed used varied from a little less than 2 bushels to almost 4 bushels per acre. The average for the three years was 2.6 bushels. Yearly averages deviated less than one-tenth of a bushel. The amount of twine used per acre averaged 2.1 pounds per acre. It varied from a little more than one pound to over 3¾ pounds. The usual threshing rate was 4 cents per bushel. When hour rates were used, the charge was the same for oats as for wheat, $4.50 to $8.00 per hour.

Standards for Oats Production

The labor standards for oats are the same as for wheat with the exception of shock-threshing. The standard for shock-threshing oats is 1.9 man hours and 3.35 horse hours. The standard for harvesting oats with a combine is the same as for wheat. The Northwest Experiment Station recommends seeding 2 bushels of seed per acre when drilled and 3 bushels when broadcast. Oats were drilled on all the farms studied. For an average yield, 2¾ pounds of twine should be sufficient.

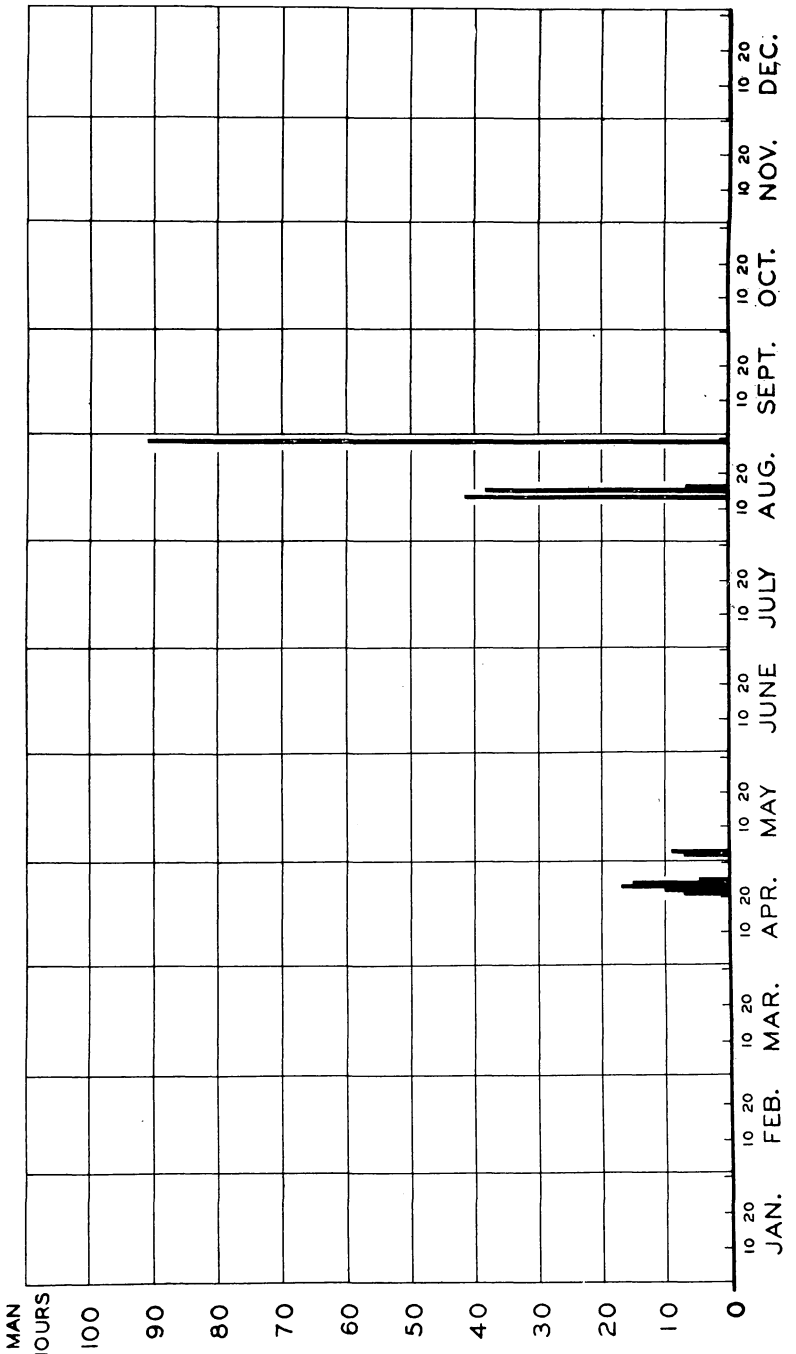

Fig. 25. Daily Distribution of Man Labor on a 48-Acre Field of Oats

Seedbed preparation and seeding of barley ordinarily follow the spring work on oats and precede the spring work on barley.

With high yields more would be required and with low yields perhaps less, depending primarily upon the amount of straw.

Distribution of Labor on Oats

The dates between which the crop operations for oats usually are performed, together with the estimated number of work days available are presented in Table 19. Seedbed preparation for oats should follow immediately the work for the wheat crop.

Table 19

Usual Dates and Work Days Available for Performing Different Field Operations on Oats

Operation	Usual dates	Work days available
Seedbed preparation	April 5 to May 7	20
Seeding	April 6 to May 7	18
Cutting	July 26 to Aug. 23	16
Threshing	Aug. 16 to Sept. 20	28

These dates may be a guide in planning the operations but will have to be shifted to allow for differences in the season.

A typical daily distribution of man labor on a 48-acre field of oats is presented in Figure 25. This field was all plowed, but as the fall plowing may be done any time between harvest and the time the ground freezes, no fall-plowing labor is shown. The work was concentrated in three periods—during seedbed preparation and seeding in the latter part of April, during harvest near the middle of August, and threshing near the end of the month.

Barley

Usual Practices in Barley Production

Preparation of the seedbed and seeding of barley usually follow oats seeding. More of the land was spring plowed for barley than for either wheat or oats, 29 per cent of the land for barley being spring plowed and 53 per cent fall plowed. The land was usually gone over with either a disk or a spring-tooth harrow—13 per cent once, 13 per cent twice, and 2 per cent three times. Approximately 25 per cent of the land was harrowed once with an ordinary spike-tooth harrow and 43 per cent twice before planting. Seventy-one per cent of the land was harrowed once after seeding. In addition, about 18 per cent of the land was covered with a roller or cultipacker.

Table 20
Man Labor Used per Acre by Operations on Barley, 1927

Farm No.	Acres per farm	Yield, bu.	Fall plowing		Spring plowing		Disking		Spring-tooth harrowing		Harrowing		Rolling*		Seeding, hours	Cutting, hours	Shocking, hours	Threshing, hours	Total man hours
			Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over					
232	134	23.7	0.79	0.93	....	....	0.10	0.12	0.94	1.75	0.02	0.07	0.05	0.31	0.36	0.33	0.70	1.69	4.98
026	48	17.3	1.90	0.94	....	....	....	....	0.69	0.94	....	....	....	....	.52	0.65	0.49	1.17	5.42
072	64	28.3	0.99	0.49	....	....	0.60	1.01	0.19	0.49	0.11	0.81	....	....	.69	0.65	0.85	1.83	5.91
231	98	17.2	1.35	0.82	....	....	....	....	1.09	1.00	0.31	1.00	....	....	.54	0.65	0.89	1.85	6.68
201	57	31.8	0.78	0.41	0.93	0.59	....	....	0.32	0.36	0.65	3.00	....	....	.61	0.66	0.91	2.09	6.95
021	54	28.1	0.87	0.66	0.52	0.49	0.20	0.45	1.03	1.59	0.22	1.25	....	....	.63	0.89	1.39	1.21	6.96
022	9	25.3	....	....	0.77	1.00	....	....	1.54	1.83	....	....	....	....	.55	0.83	1.43	1.95	7.07
024	24	25.3	....	....	1.75	1.00	0.08	0.12	....	....	....	....	.21	0.16	.68	....	1.27	3.49	7.48
025	25	22.7	2.35	1.00	....	....	0.21	0.36	0.51	1.00	0.19	0.68	.48	1.00	.48	0.65	0.71	2.01	7.59
051	27	21.3	2.00	1.00	....	....	0.64	0.77	....	....	0.29	1.00	....	....	.52	0.63	0.81	2.82	7.71
221	41	19.0	0.59	0.30	2.00	0.70	0.24	0.51	....	....	0.56	2.21	....	....	.70	1.09	0.97	1.63	7.78
161	72	38.5	2.08	1.00	....	....	0.67	1.34	....	....	0.38	2.00	....	....	.45	0.76	1.11	2.35	7.80
233	91	29.8	0.61	0.79	0.24	0.21	....	....	0.29	1.78	0.31	0.79	.09	0.29	.73	1.69	1.23	2.87	8.06
081	11	26.4	....	....	....	....	....	....	2.05	3.00	0.39	1.00	....	....	.83	0.70	1.77	2.62	8.36
023	20	25.7	2.05	0.72	....	....	....	....	1.88	1.88	0.25	1.39	.30	0.30	.56	0.86	0.76	2.30	8.96
031†	7	32.2	1.13	0.41	1.91	1.00	....	....	1.16	0.62	0.85	3.50	.34	....	.68	1.23	1.33	2.69	11.32
082	25	41.0	2.46	1.00	....	....	0.93	0.94	0.12	0.38	1.49	3.00	....	....	.75	0.87	2.46	3.67	12.75
Average																			
1927	50	26.3	1.18	0.63	0.38	0.25	0.23	0.35	0.67	1.00	0.32	1.14	.07	0.12	.60	0.74	1.11	2.22	7.52
1926	45	20.9	0.87	0.36	0.91	0.53	0.16	0.23	0.12	0.14	0.54	2.01	.20	0.24	.59	0.78	1.04	2.21	7.42
1928	47	29.9	0.79	0.48	0.28	0.22	0.24	0.46	0.17	0.41	0.42	1.70	0.13	0.28	0.56	0.78	1.22	2.22	6.81

* Includes cultipacking and pulverizing.

† Omitted from the average because not representative.

Variations in the Labor Expenditures on Barley

The expenditures of man labor, horse work, and tractor work on barley for each of the farms studied in 1927 and the average for each of the three years are presented in Tables 20 and 21. The man labor ranged from 5.0 to 12.8 hours per acre. In general, variations in the expenditures were the result of the same factors as discussed under wheat, namely, differences in (1) cropping practices; (2) variations in the size, shape, and location of the fields; (3) the size of the power unit; (4) the yield; (5) the quality of labor; and (6) the management.

Materials Used for Barley

Trebi, more commonly known as Canadian, was the variety of barley most generally grown. Velvet was just being introduced and its use was still confined to a few farms. The most common rate of seeding was 2 bushels per acre, altho it varied from 1½ to 2¾ bushels. The amount of twine used varied from 1.05 to 4.3 pounds per acre, 2⅕ pounds being the average. The common rate for threshing was 4 cents per bushel. Hour rates for threshing were the same for barley as for oats or wheat, $4.50 to $8.00 per hour.

Standards for Barley Production

Standards for seedbed preparation, seeding, and harvesting are the same for barley as for wheat with the exception that the standard for shocking barley is one hour per acre as compared with 0.9 of an hour for wheat. The standard for rolling, which has not been given, is 0.4 man hour and 1.6 horse hours per acre. The Northwest Experiment Station recommends 2 bushels of seed per acre. Two and three-fourths pounds of twine should be sufficient for a yield of about 35 bushels per acre. Less might be needed for a lower yield and more for a higher yield, the amount depending upon the amount of straw.

Distribution of Labor on Barley

The dates between which work on the barley crop is ordinarily performed, together with the estimated number of days within which field work may be done, are presented in Table 22. The computation of the date for starting seedbed preparation for barley is based on the assumption that both wheat and oats will be seeded before the barley. If either or both of these crops are not included in the cropping system, the field work for barley may start earlier. Fall plowing may be done any time between harvest and the time the ground freezes.

Table 21

Horse and Tractor Work Used per Acre by Operations on Barley, 1927

Farm No.	Acres per farm	Yield, bu.	Fall plowing			Spring plowing			Disking			Spring-tooth harrowing			Harrowing			Rolling*			Seeding		Cutting		Threshing		Total	
			Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Horse hours	Tractor hours	Horse hours	Tractor hours	Horse hours	Tractor hours
232	134	23.7	....	0.79	0.93	....	....	....	0.42	....	0.12	0.79	0.61	1.75	0.09	....	0.07	....	0.05	0.31	0.94	0.11	....	0.33	2.61	....	4.85	1.89
026	48	17.3	11.11	....	0.94	....	....	....	....	....	....	2.97	....	0.94	....	....	....	....	....	....	2.09	....	2.51	....	3.22	....	21.90	....
072	64	28.3	4.95	....	0.49	....	....	....	2.33	....	1.01	1.12	....	0.49	0.44	....	0.81	....	....	....	2.45	....	2.61	....	3.12	....	17.02	....
231	98	17.2	1.92	0.94	0.82	....	....	....	....	....	....	2.06	0.58	1.00	1.23	....	1.00	....	....	....	1.95	....	2.60	....	3.09	....	12.85	1.52
201	57	31.8	3.83	....	0.41	4.63	....	0.59	....	....	....	1.30	....	0.36	3.57	....	3.00	....	....	....	2.42	....	2.63	....	3.79	....	22.17	....
021	54	28.1	....	0.87	0.66	1.07	0.25	0.49	0.80	....	0.45	....	1.03	1.59	0.68	0.05	1.25	....	....	....	2.50	....	3.57	....	0.80	....	9.42	2.20
022	9	25.3	....	....	....	....	0.77	1.00	....	....	....	6.16	....	1.83	....	....	....	....	....	....	2.20	....	3.30	....	3.05	....	14.71	0.77
024	24	25.3	....	....	....	....	1.75	1.00	....	0.08	0.12	....	....	....	....	....	....	0.31	0.04	0.16	2.71	....	....	....	4.11	....	7.13	1.87
025	25	22.7	11.24	....	1.00	....	....	....	0.85	....	0.36	....	0.51	1.00	0.77	....	0.68	1.91	....	1.00	1.83	....	2.60	....	2.56	....	21.76	0.51
051	27	21.3	2.87	1.04	1.00	....	....	....	2.58	....	0.77	....	....	....	1.18	....	1.00	....	....	....	1.95	....	2.50	....	4.97	....	16.05	1.04
221	41	19.0	2.96	....	0.30	9.98	....	0.70	0.97	....	0.51	....	....	....	2.22	....	2.21	....	....	....	2.81	....	4.35	....	3.26	....	26.55	....
161	72	38.5	9.74	....	1.00	....	....	....	2.68	....	1.34	....	....	....	1.52	....	2.00	....	....	....	1.81	....	3.02	....	4.70	....	23.47	....
233	91	29.8	....	0.61	0.79	....	0.24	0.21	....	....	....	....	0.29	1.78	1.23	....	0.79	0.37	....	0.21	2.89	....	....	0.56	4.83	....	9.32	1.70
081	11	26.4	....	....	....	....	....	....	....	....	....	8.20	....	3.00	1.57	....	1.00	....	....	....	3.14	....	2.79	....	4.84	....	20.54	....
023	20	25.7	10.33	....	0.72	....	....	....	....	....	....	7.58	....	1.88	0.71	....	1.39	1.21	....	0.30	2.22	....	3.44	....	4.04	....	29.53	....
031†	7	32.2	5.83	....	0.41	11.05	....	1.00	....	....	....	4.64	....	0.62	3.41	....	3.50	1.36	....	....	2.73	....	4.91	....	4.84	....	38.77	....
082	25	41.0	8.90	....	1.00	....	....	....	3.07	....	0.94	0.49	....	0.38	3.30	....	3.00	....	....	....	2.61	....	3.48	....	6.95	....	28.80	....
Average																												
1927	50	26.3	4.24	0.27	0.63	0.98	0.19	0.25	0.86	....	0.35	1.92	0.19	1.00	1.16	....	1.14	0.24	....	0.12	2.28	0.01	2.46	0.06	3.75	....	17.89	0.72
1926	45	20.9	2.81	0.18	0.36	3.80	0.14	0.53	0.63	....	0.23	0.44	0.02	0.14	2.16	....	2.01	0.71	....	0.24	2.37	....	2.67	0.06	3.79	....	19.38	0.40
1928	47	29.9	2.33	0.29	0.48	0.65	0.13	0.22	0.96	....	0.46	0.26	0.11	0.41	1.62	0.01	1.70	0.43	....	0.28	2.10	0.02	1.83	0.22	3.91	....	14.09	0.78

* Includes cultipacking and pulverizing.

† Omitted from the average because not representative.

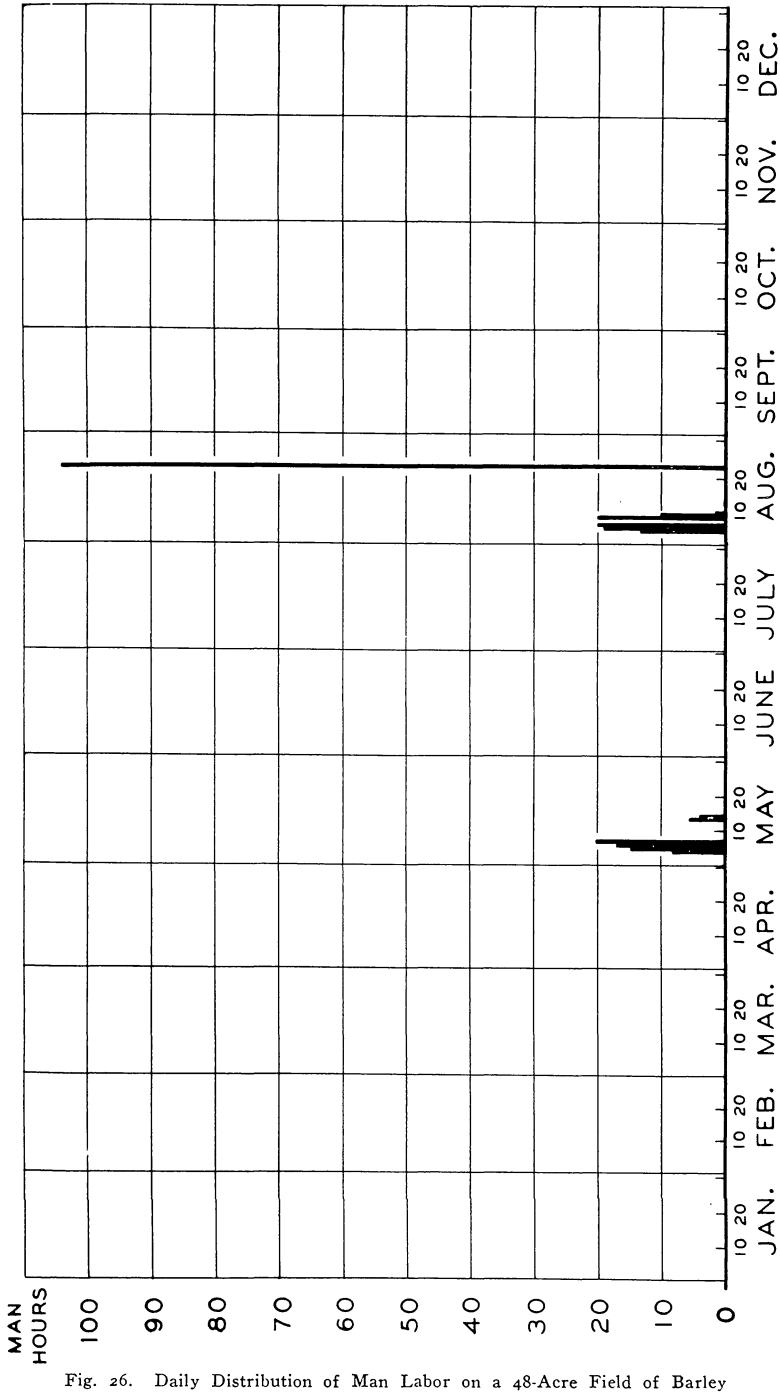

Fig. 26. Daily Distribution of Man Labor on a 48-Acre Field of Barley

Seedbed preparation and seeding of barley ordinarily follow the spring work on oats and precede that on flax.

The daily expenditure of man labor on a 48-acre field of barley is shown in Figure 26. The distribution is fairly typical of the region. The operations for barley fall into three distinct periods, one of seedbed preparation and seeding the first part of May, another of harvest the first part of August, and another for threshing the latter part of August.

Table 22

Usual Dates and Work Days Available for Performing Different Field Operations on Barley

Operation	Usual dates	Work days available
Seedbed preparation	April 18 to May 21	20
Seeding	April 22 to May 21	16
Cutting	July 26 to Aug. 22	15
Threshing	Aug. 16 to Sept. 20	28

Flax

Usual Practices in Flax Production

Work on the flax crop customarily follows that on wheat, oats, and barley. Better yields of flax usually result from early seeding. However, a fair yield of flax may be obtained from a seeding somewhat later than is possible for wheat or barley. For this reason the acreage of flax is influenced by the land remaining unplanted after the safe seeding dates for these crops. Twelve per cent of the land for flax was fall plowed and 81 per cent spring plowed. Nine per cent of the land was disked once and approximately 9 per cent disked more than once. Approximately 11 per cent of the land was covered with a spring-tooth harrow and one-half of this more than once. Twenty-four per cent of the land was covered with a spike-tooth harrow once before seeding, 19 per cent twice, and 3 per cent three or more times. Fifty-three per cent of the land was rolled, pulverized, or packed before seeding. After seeding, 6 per cent of the flax was harrowed once, 32 per cent was rolled or packed once, and 5 per cent was rolled or packed twice. Occasionally land that had not been under cultivation for several years was plowed late in the spring, perhaps rolled, and then flax was drilled on the sod without further preparation. Late seeding, together with poor seedbed preparation, resulted in low yields. On the farms studied, most of the flax was cut, bound, and threshed from the shock, altho sometimes it was never shocked and occasionally it was not bound but allowed to fall in a windrow. In the last year a combine was used on three farms. On two farms a tow mill operator threshed the flax, taking the straw in payment for the threshing. During the three years of the study, a number of farmers sold their flax straw to a tow mill at from $4.00 to $5.00 per ton.

Table 23
Man Labor Used per Acre by Operations on Flax, 1927

Farm No.	Acres per farm	Yield, bu.	Plowing		Disking		Spring-tooth harrowing		Harrowing		Rolling*		Seeding, hours	Cutting, hours	Shocking, hours	Threshing, hours	Total man hours
			Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over					
051	38	3.8	....	....	2.19	4.00	....	....	0.18	1.00	....	....	0.42	0.59	....	1.42	4.80
028	273	5.2	1.74	1.00	....	....	....	....	....	....	0.26	0.58	.48	0.89	0.57	1.59	5.53
021	53	2.8	1.34	1.00	0.36	0.45	0.42	1.09	0.19	0.99	.03	0.02	.63	1.17	0.58	1.20	5.92
231	23	7.1	0.70	1.00	....	....	....	....	....	....	.77	2.00	.78	1.01	0.66	1.30	5.22
232	86	7.4	0.81	1.00	0.43	0.89	0.37	0.51	0.21	0.90	....	....	.40	0.64	0.67	1.89	5.42
026	71	5.1	1.31	0.60	....	....	0.23	0.40	....	....	.58	1.00	.55	0.93	0.62	1.36	5.58
071	15	4.3	2.23	1.00	....	....	....	....	0.53	1.00	.46	1.00	.53	1.12	0.72	1.05	6.64
201	81	6.3	2.26	1.00	0.32	0.20	0.77	0.94	0.53	1.27	.22	0.65	.47	0.77	0.31	1.57	7.22
025	5	7.2	1.07	0.46	1.02	2.00	0.28	0.56	0.28	1.00	.56	1.00	.56	0.70	0.46	2.93	7.86
161	38	9.7	2.30	1.00	0.49	0.82	....	....	0.59	2.16	.45	1.00	.55	1.03	1.00	2.19	8.60
022	20	7.0	2.76	1.00	1.42	2.00	....	....	0.61	2.00	.59	1.00	.46	0.93	0.49	1.51	8.77
082	3	5.7	2.14	1.00	1.96	2.00	....	....	1.16	2.00	.44	1.00	.44	1.64	1.50	3.55	12.83
Average																	
1927	59	6.0	1.56	0.84	0.68	1.03	0.17	0.29	0.36	1.03	.36	0.77	.52	0.95	0.63	1.80	7.03
1926	58	7.3	1.50	0.57	0.67	1.42	0.35	0.71	0.63	1.50	.53	0.97	.52	0.88	0.72	1.72	7.52
1928	69	5.9	1.57	0.89	0.29	0.48	0.15	0.27	0.27	0.83	0.32	0.87	0.58	0.72	0.66	1.64	6.20

* Includes cultipacking and pulverizing.

Table 24

Horse and Tractor Work Used per Acre by Operations on Flax, 1927

Farm No.	Acres per farm	Yield, bu.	Plowing			Disking			Spring-tooth harrowing			Harrowing			Rolling*		Seeding		Cutting		Threshing	Total	
			Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Times over	Horse hours	Tractor hours	Horse hours	Tractor hours	Horse hours	Horse hours	Tractor hours
051	38	3.8	....	....	....	8.74	....	4.00	....	....	....	0.74	....	1.00	....	....	1.69	....	2.37	....	2.39	15.93	....
028	273	5.2	4.60	1.17	1.00	....	....	....	....	....	....	....	....	....	1.04	0.58	1.94	....	3.56	....	2.87	14.01	1.17
021	53	2.8	0.13	1.31	1.00	1.41	....	0.45	....	0.42	1.09	0.77	....	0.99	0.06	0.02	2.53	....	....	0.63	0.84	5.74	2.36
231	23	7.1	....	1.19	1.00	....	....	....	....	....	....	....	....	....	3.08	2.00	2.95	....	4.05	....	2.09	12.17	1.19
232	86	7.4	....	0.81	1.00	1.44	0.07	0.89	1.00	.12	0.51	0.14	0.17	0.90	....	....	....	0.40	2.02	.14	2.39	6.99	1.71
026	71	5.1	7.75	....	0.60	....	....	....	1.07	....	0.40	....	....	....	2.30	1.00	2.08	....	3.65	....	2.38	19.23	....
071	15	4.3	11.85	....	1.00	....	....	....	....	....	....	2.10	....	1.00	1.58	1.00	2.10	....	4.46	....	2.10	24.19	....
201	81	6.3	11.62	....	1.00	1.28	....	0.20	4.49	....	0.94	2.84	....	1.27	0.89	0.65	1.87	....	3.08	....	3.01	29.08	....
025	5	7.2	5.25	....	0.46	1.86	.56	2.00	....	.28	0.56	1.12	....	1.00	2.23	1.00	2.23	....	2.79	....	6.13	21.61	0.84
161	38	9.7	11.36	....	1.00	1.98	....	0.82	....	....	....	2.37	....	2.16	0.90	1.00	1.45	....	3.90	....	3.85	25.81	....
022	20	7.0	1.46	2.39	1.00	5.66	....	2.00	....	....	....	2.44	....	2.00	2.34	1.00	1.86	....	3.71	....	3.03	20.50	2.39
082	3	5.7	8.10	....	1.00	3.20	....	2.00	....	....	....	2.31	....	2.00	0.89	1.00	1.78	....	3.28	....	6.00	25.56	....
Average																							
1927	59	6.0	5.18	0.57	0.84	2.13	.05	1.03	0.55	.07	0.29	1.24	.01	1.03	1.28	0.77	1.87	.03	3.07	.06	3.09	18.40	0.73
1926	58	7.3	6.93	0.13	0.57	2.68	....	1.42	1.34	....	0.71	2.15	....	1.50	1.80	0.97	1.91	....	2.92	.07	2.61	22.34	0.20
1928	69	5.9	3.01	0.77	0.89	1.07	0.02	0.48	0.49	0.02	0.27	0.95	0.03	0.83	1.28	0.87	1.93	0.05	1.78	0.19	3.01	13.52	1.08

* Includes cultipacking and pulverizing.

Variations in Labor Expenditures on Flax

The expenditures of man labor, horse work, and tractor work on flax for each of the farms studied in 1927 and the average for 1926, 1927, and 1928 are given in Tables 23 and 24. The total man labor expenditure varied from 4.8 to 10.1 hours in 1927, with an average of 6.7 hours. The yearly average was considerably higher in 1926 than in either of the other two years, largely because of more thoro seedbed preparation and a higher yield. In general, the variations are due to the same factors as were discussed under wheat. The labor expenditure on Farm 051 was low partly because the flax was not shocked. Farm 082 had a high labor expenditure because of inefficiency of operation due to small acreage, use of small power units, and a long distance between the fields and the farmstead.

Materials Used for Flax

Seeding rates for flax varied from 22 to 42 pounds per acre, averaging 31 pounds for the three years. When the crop was bound the amount of twine used varied from one pound to a little over 3 pounds per acre with an average of 1¾ pounds. The usual threshing rate was 12 cents per bushel. Hour rates were the same as for the small grains.

Standards for Flax Production

The standards for the operations in seedbed preparation and seeding of flax are the same as for the small-grain crops. The per-acre standards for harvesting with a binder and shock threshing, assuming a yield of 10 bushels per acre, are as shown in Table 25. With higher or lower yields the expenditures would be correspondingly more or less. Standards for combining are the same as presented in the discussion of the wheat crop. Twenty-eight pounds of seed per acre of the small-seeded and 42 pounds of the large-seeded varieties are the amounts recommended by the Northwest Experiment Station. Two pounds of twine should be sufficient for a yield of about 10 bushels.

Table 25
Standards per Acre for the Harvesting and Shock Threshing of Flax

Operation	Man hours	Horse hours
Cutting with 8-ft. binder	0.8	3.20
Shocking	0.8	....
Threshing	1.9	3.10

Distribution of Labor on Flax

The dates between which the operations on flax are most commonly performed, together with the probable number of days during which

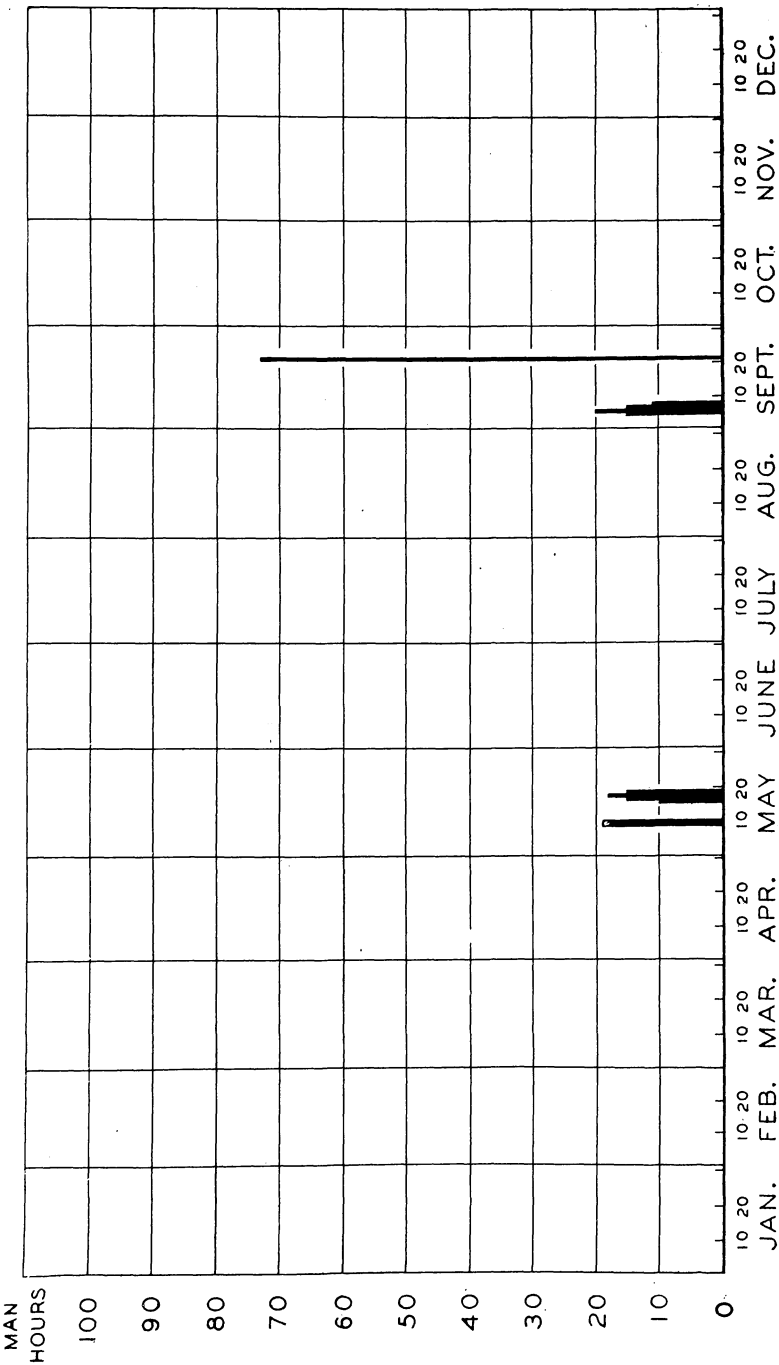

Fig. 27. Daily Distribution of Man Labor on a 38-Acre Field of Flax
Seedbed preparation and seeding of flax ordinarily follow those for barley.

weather and soil conditions will permit field work to be done, are presented in Table 26. It must be kept in mind that the work on the flax crop follows that on wheat, oats, and barley, and hence will be governed by the progress of work on the other crops.

Table 26

Usual Dates and Work Days Available for Performing Different Field Operations on Flax

Operation	Usual dates	Work days available
Seedbed preparation	April 30 to June 10	26
Seeding	May 13 to June 15	18
Cutting	Aug. 13 to Sept. 20	30
Threshing	Sept. 1 to Oct. 15	28

The daily expenditure of man labor on a 38-acre field of flax is shown in Figure 27. This distribution is typical for the region. The labor is concentrated in three periods, namely, a week of seedbed preparation and seeding about the middle of May, four days of harvesting in September, and one day of threshing in the latter part of September.

Potatoes

Usual Practices in Potato Production

The acreage of potatoes on the farms studied was large enough that the potatoes were planted, cultivated, and dug with machines. The land for potatoes was plowed in the fall when possible. Occasionally a field was plowed both fall and spring. The land plowed in the fall varied from 35 to 79 per cent with an average of 70 per cent for the three years. Twelve per cent of the land was disked once, 18 per cent twice, and 8 per cent from three to eight times. Eleven per cent of the land was gone over once with a spring-tooth harrow, 39 per cent twice, and 8 per cent three or four times. Twenty-five per cent of the land was harrowed once, 40 per cent twice, and 25 per cent three times before planting. After planting, 40 per cent was harrowed once and 10 per cent more than once. The number of cultivations varied from one to seven. Fifty per cent of the potatoes were cultivated three times and 25 per cent four times. A little over half the land was covered with a weeder. Forty-six per cent of the acreage was sprayed once, 40 per cent twice, and 9 per cent three times. Rogueing was a common practice if the potatoes were to be certified. The larger part of the production was stored in pits or cellars on the farm and then marketed during late winter or early spring. This was particularly true of the certified seed potatoes. In numerous cases potato picking was hired and the pickers were paid by the bushel.

Variations in Labor Expenditures on Potatoes

The labor expenditures varied, largely as a result of the same causes as were discussed under wheat. Differences in cultural practices were perhaps a little more important than with wheat because of the increased number of possible operations. The total expenditure of man labor per acre in 1927 varied from approximately 32 to 65 hours. The labor expenditures per acre by operations for each of the farms studied in 1927 and the average for each of the three years of the study are presented in Tables 27 and 28.

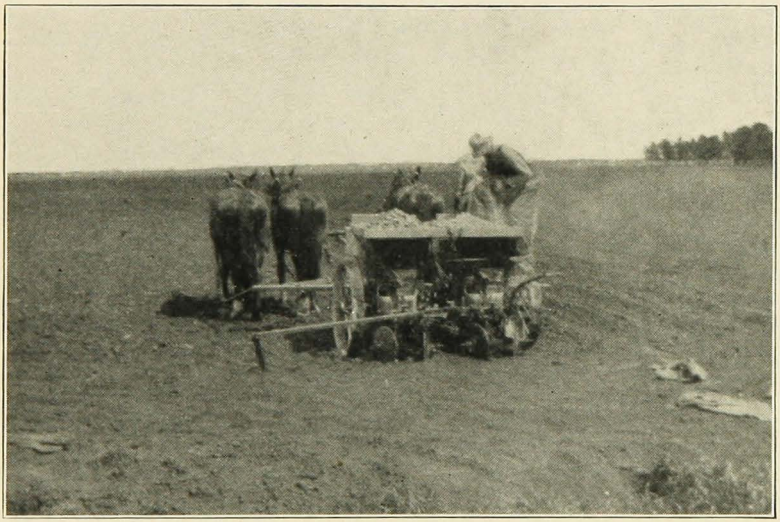

Fig. 28. Planting Potatoes in the Red River Valley
The two-row planter is commonly used on farms growing large acreages of potatoes.

Materials Used in Potato Production

The Early Ohio is the variety of potatoes most generally grown on the farms studied. However, the growers on the better potato soils close to the Red River, who planted large acreages, grew largely the Irish Cobbler. These men were producing for a specialized seed trade. From 10 to 14 bushels of seed were generally used, altho the producers of certified seed on the better soil used as much as 28 bushels of seed per acre. The amount of spray material varied from nothing to over 10 pounds per acre. Paris green was the common spray material altho some bordeaux mixture, arsenate of lead, and zinc arsenite were used in a few cases. The common rates for picking potatoes varied from 4 to 5 cents per bushel. Most of the potatoes were sold in bulk. When sacked, the purchaser sometimes paid the grower for the sacks. Sacks holding 120 pounds cost from 11 to 13 cents each.

Table 27

Man Labor Used per Acre by Operations on Potatoes, 1927

Farm No.	Acres per farm	Yield, bu.	Plowing		Disking		Spring-tooth harrowing		Harrowing		Weeding		Rolling		Cutting seed, hours	Planting, hours	Cultivating		Hoeing, hours	Spraying		Digging, hours	Picking, grading, hauling, hours	Total man hours
			Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over			Hours	Times over		Hours	Times over			
233	9	67	1.29	1.00	....	....	1.37	4.00	0.45	1.00	....	....	....	....	5.33	2.97	5.66	4.00	....	0.84	2.00	2.41	11.88	32.20
025	7	59	2.36	1.00	....	....	1.38	2.00	0.36	2.00	....	....	....	....	3.66	1.70	7.07	4.00	....	0.43	1.00	1.99	13.44	32.39
221	2	19	5.09	0.96	....	....	....	....	0.46	1.93	....	....	....	....	5.56	4.17	6.94	2.89	2.31	....	....	2.78	6.71	34.02
023	23	56	2.36	1.00	....	....	0.79	2.00	0.98	2.05	....	....	....	....	4.44	1.79	6.41	4.00	2.27	2.25	3.00	1.97	11.68	34.94
081	2	60	4.00	1.00	....	....	1.23	1.00	0.63	1.00	....	....	....	....	4.00	3.63	5.25	4.00	....	1.25	1.00	3.63	12.38	36.02
051	6	86	1.99	1.00	2.17	2.00	0.45	1.00	1.17	3.00	....	....	....	....	2.89	1.90	3.16	2.98	....	0.54	1.00	2.62	21.39	38.28
031*	7	64	2.47	1.00	....	....	....	....	0.46	2.10	2.12	3.50	....	....	9.37	2.12	8.19	3.00	....	1.37	1.00	2.81	10.32	39.23
232	4	162	....	....	1.26	1.00	0.16	2.00	0.49	1.00	....	....	....	....	5.90	3.09	4.21	3.00	....	1.97	2.00	2.53	19.38	39.39
082	18	126	2.04	1.00	0.78	1.02	0.85	0.70	1.02	2.57	0.85	1.08	....	....	8.72	1.64	8.58	4.00	....	1.50	1.35	2.25	11.28†	39.51
231	7	103	0.55	0.38	0.37	0.62	....	....	1.03	2.00	....	....	....	....	6.32	2.24	5.11	3.38	0.81	3.35	2.31	2.02	17.87	39.67
026	2	61	4.17	1.00	....	....	....	....	0.98	2.00	....	....	....	....	6.74	2.70	4.41	3.00	4.66	5.64	1.00	3.68	6.86	39.84
021	7	60	1.38	1.00	....	....	3.31	2.00	0.69	1.00	....	....	....	....	5.15	2.81	8.81	4.50	....	3.12	3.00	2.81	15.50	43.58
201	3	69	1.10	1.00	....	....	....	....	0.55	3.00	....	....	....	....	8.20	4.26	4.42	2.00	....	1.42	1.00	3.15	18.61	41.71
161	13	149	4.30	1.00	1.16	2.00	....	....	0.80	2.02	0.35	0.98	0.22	0.25	6.85	2.35	7.40	4.98	0.51	1.90	2.00	2.20	20.60	48.64
032*	3	54	5.43	1.00	....	....	1.76	2.53	0.08	0.12	0.88	1.00	....	....	9.09	3.52	11.44	3.00	....	0.88	1.00	6.67	12.39	52.14
022	4	105	1.69	1.00	....	....	0.72	1.00	0.48	1.00	....	....	.96	1.00	3.01	2.17	13.98	4.00	12.05	3.49	3.00	3.98	22.65	65.18
Average																								
1927	8	84	2.31	0.88	0.41	0.47	0.76	1.12	0.72	1.83	0.09	0.15	.08	0.09	5.48	2.67	6.53	3.62	1.62	1.98	1.69	2.72	15.01‡	40.38
1926	9	78	2.27	0.93	0.44	0.72	0.42	0.67	0.92	3.32	0.43	0.29	.06	0.08	4.96	2.07	7.17	5.26	2.01	2.19	1.28	3.00	10.81§	36.75
1928	10	72	2.25	1.25	0.52	0.83	0.35	0.62	1.25	2.50	0.17	0.17	0.18	0.25	5.04	2.12	7.06	3.69	2.81	0.98	1.43	2.18	14.18‖	39.09
1928**	76	164	1.78	0.95	0.47	0.73	1.03	1.22	0.86	2.72	2.24	1.20	....	....	7.99	2.39	4.64	3.51	2.06	0.68	1.07	2.04	13.88¶	40.36

* Omitted from the average because not representative.

† Does not include picking labor paid on a bushel basis amounting to $1.15 per acre.

‡ Does not include picking labor paid on a bushel basis amounting to 7 cents per acre.

§ Does not include picking labor paid on a bushel basis amounting to $1.09 per acre.

‖ Does not include picking labor paid on a bushel basis amounting to 89 cents per acre.

** Average for large potato producers on the better potato soil. These farms are not included in the other average for 1928.

¶ Does not include picking labor paid on a bushel basis amounting to $1.88 per acre.

Table 28

Horse and Tractor Work Used per Acre by Operations on Potatoes, 1927

Farm No.	Acres per farm	Yield, bu.	Plowing			Disking		Spring-tooth harrowing			Harrowing		Weeding		Rolling		Planting	Cultivating		Spraying		Digging		Picking, hauling	Total	
			Horse hours	Tractor hours	Times over	Horse hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Times over	Horse hours	Times over	Horse hours	Times over	Horse hours	Horse hours	Times over	Horse hours	Times over	Horse hours	Tractor hours	Horse hours	Horse hours	Tractor hours
233	9	67	....	1.29	1.00	....	....	....	1.37	4.00	1.77	1.00	....	....	....	....	5.83	11.32	4.00	1.91	2.00	9.64	....	7.29	37.76	2.66
025	7	59	11.27	....	1.00	....	....	....	1.38	2.00	1.45	2.00	....	....	....	....	3.41	14.49	4.00	0.87	1.00	7.97	....	8.19	47.65	1.38
221	2	19	25.46	....	0.96	....	....	....	....	....	1.85	1.93	....	....	....	....	8.33	13.88	2.89	....	....	5.66	....	....	55.08	....
023	23	56	11.78	....	1.00	....	....	3.14	....	2.00	2.89	2.05	....	....	....	....	3.41	12.81	4.00	4.42	3.00	8.31	....	11.13	57.89	....
081	2	60	16.00	....	1.00	....	....	2.50	....	1.00	1.25	1.00	....	....	....	....	7.25	10.50	4.00	2.50	1.00	14.50	....	4.00	58.50	....
051	6	6	4.33	0.90	1.00	8.66	2.00	1.81	....	1.00	4.69	3.00	....	....	....	....	7.04	6.32	2.98	1.08	1.00	10.47	....	2.53	46.93	0.99
031*	7	64	14.30	....	1.00	....	....	....	....	....	1.82	2.50	4.24	3.50	....	....	4.25	16.39	3.00	1.21	1.00	10.32	....	8.04	60.57	....
232	4	162	....	....	....	5.06	1.00	1.40	0.21	2.00	1.97	1.00	....	....	....	....	6.18	8.43	3.00	3.94	2.00	10.11	....	15.45	52.54	0.21
082	18	126	7.72	....	1.00	3.11	1.02	3.40	....	0.70	2.63	2.57	2.10	1.08	....	....	3.28	16.82	4.00	1.30	1.35	7.98	....	3.03	51.37	....
231	7	103	2.46	....	0.38	1.47	0.62	....	....	....	4.08	2.00	....	....	....	....	3.90	11.10	3.38	4.26	2.31	7.50	....	3.75	38.52	....
026	2	61	8.33	....	1.00	....	....	....	....	....	3.19	2.00	....	....	....	....	5.39	8.82	3.00	....	1.00	14.71	....	6.86	47.30	....
021	7	60	....	1.38	1.00	....	....	9.54	0.69	2.00	2.77	1.00	....	....	....	....	5.62	17.62	4.50	4.54	3.00	....	2.27	7.92	48.01	4.34
201	3	69	6.55	....	1.00	....	....	....	....	....	2.84	3.00	....	....	....	....	8.52	8.83	2.00	2.84	1.00	12.62	....	5.05	47.25	....
161	13	149	20.21	....	1.00	4.63	2.00	....	....	....	3.22	2.02	0.71	0.98	0.43	0.25	4.71	14.80	4.98	3.81	2.00	7.53	....	5.73	65.78	....
032*	3	54	16.13	....	1.00	....	....	7.06	....	2.53	0.15	0.12	1.76	1.00	....	....	7.04	22.88	3.00	....	1.00	13.78	....	8.80	77.60	....
022	4	105	....	1.69	1.00	....	....	2.89	....	1.00	0.96	1.00	....	....	3.86	1.00	4.34	25.66	4.00	5.54	3.00	12.05	....	13.26	68.56	1.69
Average																										
1927	8	84	8.15	0.38	0.88	1.64	0.47	1.76	0.26	1.12	2.54	1.83	0.20	0.15	0.31	0.09	5.52	12.96	3.62	2.64	1.69	9.21	0.16	6.73	51.66	0.80
1926	9	78	9.89	0.07	0.93	1.74	0.72	1.55	0.03	0.67	3.35	3.32	0.35	0.29	0.13	0.08	4.08	13.94	5.26	3.14	1.28	9.77	....	6.68	54.62	0.10
1928	10	72	7.27	0.73	1.25	2.08	0.83	0.66	0.12	0.62	4.81	2.50	0.35	0.17	0.49	0.25	4.27	13.53	3.69	1.62	1.43	6.52	0.34	3.91	45.51	1.19
1928†	76	164	5.98	0.50	0.95	1.89	0.73	4.38	....	1.22	3.25	2.72	1.33	1.20	....	....	5.56	13.34	3.51	1.07	1.05	6.67	0.24	39.69	83.16	0.74

* Omitted from the average because not representative.

† Average for large potato producers on the better potato soil. These farms are not included in the other average for 1928.

Standards for Potato Production

The standards for seedbed preparation for potatoes are the same as those for the small grains. The standards for the other operations are indicated in Table 29.

Table 29
Standards per Acre for Potatoes

Operation	Implement	Man hours	Horse hours	Acres over in 10-hour day
Cutting seed	.....	3.5	...	....
Planting	1-row planter, 2 horses ...	1.8	3.6	5.5
Cultivating	1-row cultivator	1.3	2.6	7.7
Spraying	.....	0.9	1.8	11.1
Digging	1-row digger, 4 horses	1.8	7.2	5.5
Picking and hauling	.....	13.0	5.0	....
Miscellaneous	.....	3.8	...	....

The standard for picking and hauling is a combined standard because in many cases the one who hauls also does some picking.

From 12 to 18 bushels of seed per acre are recommended by the Northwest Experiment Station. Two pounds of paris green, 4 pounds of lime, and 4 pounds of copper sulfate per acre should be sufficient for two sprayings, the first with paris green alone and the second with a combination of paris green and bordeaux mixture. Other arsenical compounds may be substituted for paris green, the amounts required varying with their relative strength. When 16 per cent superphosphate results in greater returns, an application of 250 pounds per acre is suggested.

Distribution of Labor on Potatoes

The dates during which the operations for potatoes are commonly performed, and the number of days available, are indicated in Table 30.

Table 30
Usual Dates and Work Days Available for Performing Different Field Operations on Potatoes

Operation	Usual dates	Work days available
Seedbed preparation	April 25 to June 5	26
Planting	May 10 to June 5	19
Cultivating	June 1 to July 30	40
Spraying	July 10 to Aug. 1	15
Digging	Sept. 25 to Oct. 10	10

The daily expenditure of man labor on a 23-acre field of potatoes is indicated in Figure 29. Since cutting seed and picking are ordinarily done by temporary help, hired for this particular work, the labor for these two operations is indicated separately. The labor in August is largely hand hoeing. A large amount of labor is required during planting and harvesting, but as seed cutting and picking are usually done with contract labor these two periods do not represent so heavy a burden on the regular force as a glance at the chart might lead one to believe.

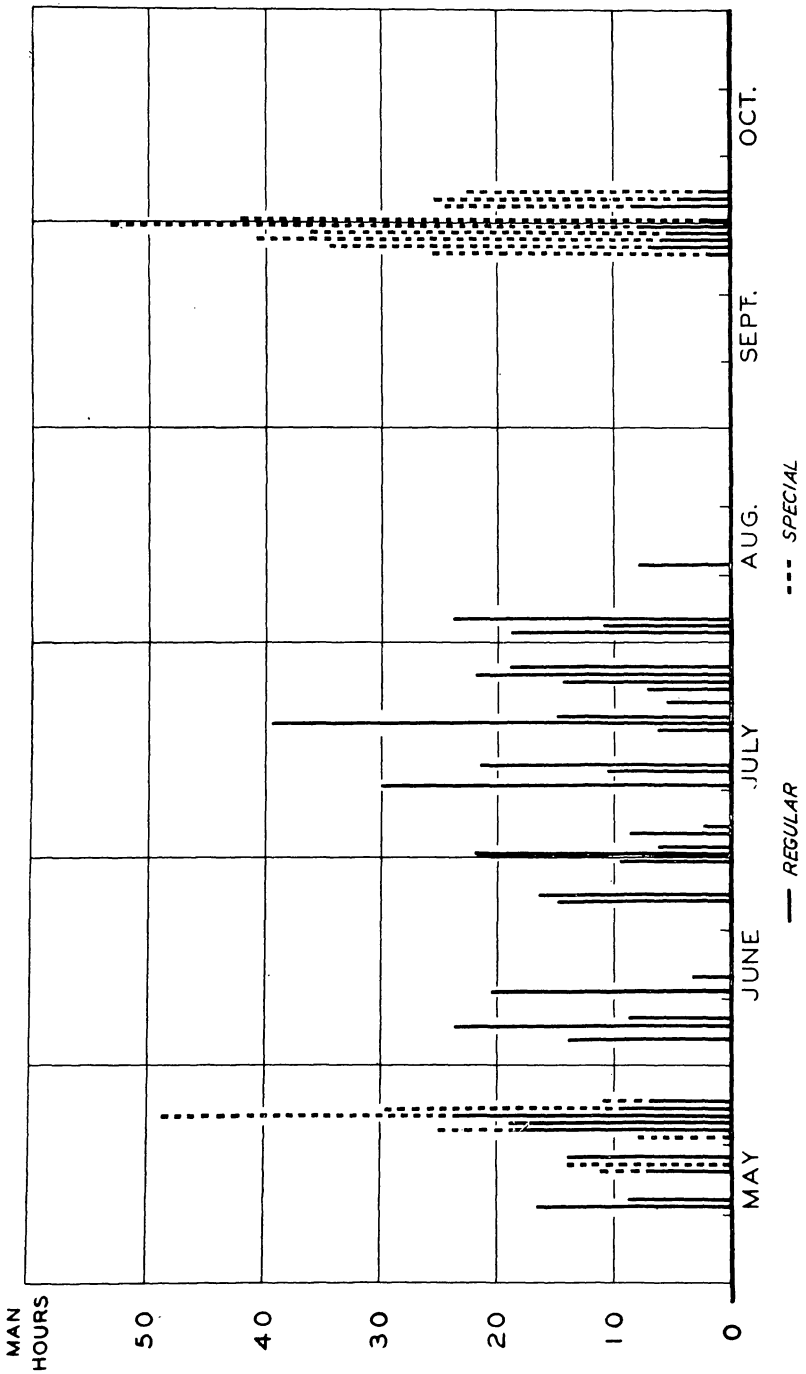

Fig. 29. Daily Distribution of Man Labor on a 23-Acre Field of Potatoes

The dotted portion of the lines represents labor for cutting seed and picking up the potatoes. These jobs are frequently done by hired laborers paid by the bushel. Work on the potato crop comes at approximately the same time as that on corn and sugar beets.

Corn

Usual Practices in Corn Production

The land for corn was practically all plowed, averaging about half in the fall and half in the spring. The relative proportions varied from year to year. Approximately 10 per cent of the land was disked once, 24 per cent twice, and 5 per cent more than twice, in some cases as many as six times. The spring-tooth harrow or the field cultivator was used once on 7 per cent, twice on 25 per cent, and three or more times on 8 per cent of the land. Thirty-three per cent of the land was harrowed once before it was planted, 39 per cent twice, 18 per cent three times, and 4 per cent from four to six times. About 46 per cent of the land was harrowed once after planting and 14 per cent twice. In addition, 20 per cent of the land was rolled or packed. The number of cultivations varied from one to eight, with about 58 per cent of the crop evenly divided between three and four times, and 37 per cent divided equally between two and five times. Planting was done with a two-row planter. Ordinarily, corn for silage or fodder was drilled, but some checked corn was cut for fodder. Owing to the small acreages grown on the farms studied, the use of one-row cultivators was practically universal. Only 3 per cent of the crop was husked from standing stalks and this was largely husked and hauled in as it was needed for feed. Forty-one per cent of the corn was put in the silo, 44 per cent cut and shocked, and 10 per cent hogged off. Two per cent of the crop was not harvested, largely because seeding was too late for a crop to mature or because the corn drowned out. Corn for silage or fodder was generally cut with a binder.

Variations in Labor Expenditures on Corn

The expenditures of man labor, horse work, and tractor work on corn up to harvest time in 1927 and the average expenditures for each of the three years are given in Tables 31 and 32. The total amount of man labor per farm in 1927 varied from 4.6 to 17.8 hours, and for the three years averaged 10.3 hours. Important causes of this variation were the differences in the number of operations performed in seedbed preparation and the number of times the field was cultivated. Other causes were those outlined in the discussion of the wheat crop. The expenditures for harvesting are presented in Table 33. The method of harvesting will further affect the amount of labor expended on an acre of corn. Silo filling requires more labor per acre than cutting and shocking. Hogging-off takes practically no labor except for the construction of temporary fences.

Table 31
Man Labor Used per Acre by Operations on Corn up to Harvest, 1927

Farm No.	Acres per farm	Fall plowing		Spring plowing		Disking		Spring-tooth harrowing		Harrowing		Rolling*		Planting		Cultivating		Total man hours
		Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over	
232	46	0.70	1.00	....	....	0.87	2.00	0.91	2.00	0.22	1.00	....	....	0.58	1.00	1.33	2.00	4.61
233	27	1.07	1.00	....	....	....	....	0.98	2.00	0.25	2.00	....	....	0.83	1.00	3.05	2.00	6.18
231	30	1.51	1.00	0.76	0.40	0.31	0.70	1.58	2.00	0.52	3.00	....	....	0.78	1.00	2.50	3.00	7.96
026	25	....	....	2.13	1.00	0.16	0.33	....	....	1.01	2.00	....	....	0.68	1.00	4.10	3.00	8.08
201	20	1.04	0.50	0.54	0.50	0.22	0.50	1.29	0.99	0.62	2.01	....	....	1.44	1.00	3.09	2.00	8.24
024	38	....	....	1.97	1.00	....	....	0.10	0.18	0.20	0.91	0.42	0.62	1.02	1.00	5.34	1.67	9.05
021	24	0.51	0.38	1.66	0.97	....	....	0.83	1.92	0.62	0.95	....	....	1.16	1.00	4.77	2.22	9.55
161	22	0.06	0.02	1.25	0.98	0.16	0.16	....	....	0.54	3.67	0.67	0.98	1.08	1.00	5.86	3.99	9.62
023	17	2.00	1.00	....	....	....	....	0.61	2.00	1.36	2.00	....	....	0.75	1.00	5.03	5.00	9.75
081	28	2.51	1.00	1.96	0.54	....	....	1.30	1.85	0.72	1.00	....	....	0.90	1.00	3.10	2.98	10.49
051	17	1.65	0.83	....	....	1.53	2.35	0.71	1.14	0.92	2.65	....	....	0.78	1.00	6.18	3.31	11.77
071	20	0.66	0.21	2.34	1.00	....	....	1.03	1.16	0.71	2.00	....	....	0.98	1.00	6.45	3.79	12.17
221	9	2.00	1.00	3.68	1.00	....	....	....	....	0.86	4.00	....	....	1.73	1.00	4.05	3.00	12.32
025	8	1.64	0.70	1.36	0.30	1.42	2.30	0.35	0.70	0.66	2.00	0.19	0.25	0.92	1.00	3.91	3.00	12.45
031†	23	0.55	0.26	1.55	0.61	0.15	0.13	0.61	0.77	1.09	3.23	....	....	0.95	1.00	8.74	4.54	13.64
082	14	2.91	1.04	0.42	0.26	0.54	0.81	0.29	0.87‡	1.16	2.10	0.04	0.10	1.08	1.00	7.23	3.00	13.67
032†	5	....	....	4.15	1.00	....	....	0.87	2.00	0.98	2.00	....	....	1.64	1.00	8.41	5.00	16.05
022	7	2.91	1.00	1.01	1.00	....	....	1.49	3.00	2.10	5.00	1.08	2.00	0.88	1.00	8.32	5.00	17.79
Average																		
1927	22	1.32	0.67	1.19	0.56	0.33	0.57	0.72	1.24	0.78	2.28	0.15	0.25	0.97	1.00	4.77	3.06	10.23
1926	29	0.73	0.36	1.42	0.68	0.37	0.72	0.58	0.46	0.83	2.88	0.10	0.18	0.90	1.00	5.76	4.12	10.69
1928	14	1.11	0.62	0.71	0.42	0.69	1.03	0.24	0.66	0.85	2.22	0.10	0.16	1.01	1.00	5.16	3.39	9.87

* Includes pulverizing and cultipacking.

† Omitted from the average because not representative.

‡ Weeder used instead of a spring-tooth harrow on this farm.

Table 32
Horse and Tractor Work Used per Acre by Operations on Corn up to Harvest, 1927

Farm No.	Acres per farm	Fall plowing			Spring plowing			Disking		Spring-tooth harrowing			Harrowing		Rolling*		Planting		Cultivating		Total	
		Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Times over	Horse hours	Times over	Horse hours	Times over	Horse hours	Times over	Horse hours	Tractor hours
232	46	....	0.70	1.00	....	....	....	3.46	2.00	1.99	0.41	2.00	0.87	1.00	....	....	1.17	1.00	4.27	2.00	11.76	1.11
233	27	....	1.07	1.00	....	....	....	....	....	....	0.98	2.00	1.02	2.00	....	....	1.65	1.00	6.09	2.00	8.76	2.05
231	30	6.55	....	1.00	1.82	0.19	0.40	1.23	0.70	4.81	0.38	2.00	2.07	3.00	....	....	1.55	1.00	7.68	3.00	25.71	0.57
026	25	....	....	....	11.98	....	1.00	0.64	0.33	....	....	....	3.62	2.00	....	....	1.37	1.00	8.20	3.00	25.81	....
201	20	5.19	....	0.50	3.28	....	0.50	0.89	0.50	5.64	....	0.99	3.27	2.01	....	....	2.87	1.00	6.19	2.00	27.33	....
024	38	....	....	....	0.52	1.19	1.00	....	....	....	0.10	0.18	0.80	0.91	0.84	0.62	2.04	1.00	9.01	1.67	13.21	1.29
021	24	....	0.51	0.38	2.55	1.02	0.97	....	....	2.68	0.16	1.92	2.47	0.95	....	....	2.70	1.00	9.54	2.22	19.94	1.60
161	22	0.26	....	0.02	6.16	....	0.98	0.64	0.16	....	....	....	2.16	3.67	1.33	0.98	1.93	1.00	11.91	3.99	24.39	....
023	17	9.91	....	1.00	....	....	....	....	....	2.43	....	2.00	4.86	2.00	....	....	1.50	1.00	10.60	5.00	29.30	....
081	28	9.99	....	1.00	7.84	....	0.54	....	....	4.99	....	1.85	1.86	1.00	....	....	1.81	1.00	6.21	2.98	32.70	....
051	17	2.89	0.81	0.83	....	....	....	6.14	2.35	2.75	....	1.14	3.67	2.65	....	....	1.56	1.00	12.36	3.31	29.37	0.81
071	20	3.13	....	0.21	10.85	....	1.00	....	....	4.10	....	1.16	2.83	2.00	....	....	1.95	1.00	12.90	3.79	35.76	....
221	9	10.00	....	1.00	18.38	....	1.00	....	....	....	....	....	3.46	4.00	....	....	3.46	1.00	8.11	3.00	43.41	....
025	8	7.87	....	0.70	5.44	....	0.30	5.69	2.30	....	0.35	0.70	2.65	2.00	0.76	0.25	1.83	1.00	11.82	3.00	36.06	0.35
031†	23	2.75	....	0.26	2.44	1.14	0.61	0.62	0.13	2.25	....	0.77	4.21	3.23	....	....	1.89	1.00	15.19	4.54	29.35	1.14
082	14	10.20	....	1.04	1.45	....	0.26	2.17	0.81	1.16	....	0.87	2.31	2.10	0.07	0.10	1.77	1.00	14.32	3.00	33.45	....
032†	5	....	....	....	8.08	....	1.00	....	....	1.75‡	....	2.00	2.62	2.00	....	....	2.84	1.00	16.81	5.00	32.10	....
022	7	....	2.91	1.00	....	1.01	1.00	....	....	5.95	....	3.00	5.41	5.00	2.17	2.00	1.76	1.00	16.64	5.00	31.93	3.92
Average																						
1927	22	4.12	0.38	0.67	4.39	0.21	0.56	1.30	0.57	2.28	0.15	1.24	2.71	2.88	0.32	0.25	1.93	1.00	9.74	3.06	26.79	0.74
1926	29	3.15	....	0.36	6.32	0.16	0.68	1.49	0.72	1.02	....	0.46	3.13	2.88	0.29	0.18	1.79	1.00	12.44	4.12	29.63	0.16
1928	14	3.70	0.32	0.62	2.08	0.28	0.42	2.73	1.03	0.55	0.11	0.66	3.21	2.22	0.31	0.16	1.76	1.00	11.45	3.39	25.79	0.75

* Includes pulverizing and cultipacking.

† Omitted from the average because not representative.

‡ Weeder used instead of a spring-tooth harrow on this farm.

Table 33

Man Labor and Horse Work Used per Acre by Operations on Harvesting Corn, 1927

Farm No.	Yield: Silage, tons	Yield: Fodder, tons	Cutting: Man hours	Cutting: Horse hours	Cutting: Times over	Shocking: Man hours	Shocking: Times over	Silo Filling: Man hours	Silo Filling: Horse hours	Silo Filling: Times over	Total: Man hours	Total: Horse hours
232	4.9	0.9	1.24	3.54	1.00	....	....	2.71	4.22	0.44	3.95	7.76
233	...	0.9	1.73	5.19	1.00	2.03	1.00	....	....	....	3.76	5.19
231	6.1	4.1	1.70	4.93	1.00	1.83	0.62	4.47	6.34	0.38	8.00	11.27
026	4.0	...	1.78	6.59	1.00	....	....	5.13	6.91	1.00	6.91	13.50
201	...	1.0	1.14	4.55	1.00	1.44	1.00	....	....	....	2.58	4.55
024	3.2	2.0	1.61	4.52	0.88	1.44	0.39	3.14	4.07	0.49	6.19	8.89
021	...	0.8	0.62	2.47	0.41	0.90	0.41	....	....	....	1.52	2.47
161	3.8	...	0.69	2.39	1.00	....	....	7.93	10.21	1.00	8.62	12.60
023	4.3	2.2	2.15	5.75	1.00	2.28	0.59	3.80	4.74	0.41	8.23	10.49
081	2.9	...	1.27	3.62	1.00	....	....	6.04	6.37	0.93	7.31	9.99
051	...	1.4	1.35	5.17	1.00	2.44	1.00	....	....	....	3.79	5.17
071	1.6	...	1.78	7.13	1.00	....	....	2.22	3.03	1.00	4.00	10.16
221	...	0.7	1.41	5.62	1.00	1.41	1.00	....	....	....	2.82	5.62
025	...	2.4	1.58	6.32	0.70	3.73	0.70	....	....	....	5.31	6.32
031*	3.9	0.9	2.49	6.87	1.00	0.34	0.39	7.72	13.87	0.61	10.55	20.74
082	...	1.2	1.50	4.23	0.90	3.51	0.86	....	....	....	5.01	4.23
032*	0.5	...	1.97	7.86	1.00	....	....	2.73	4.15	1.00	4.70	12.01
022	...	0.4	3.04†	2.44	1.00	....	....	....	....	....	3.04	2.44
Average												
1927	3.8	1.5	1.54	4.68	0.93	1.32	0.47	2.21	2.87	0.35	5.07	7.55
1926	3.5	2.8	1.43	4.65	0.85	0.95	0.49	1.57	2.16	0.34	3.95	6.81
1928	3.8	1.8	1.74	5.44	1.00	1.65	0.48	2.17	3.13	0.36	5.56	8.57

1 Omitted from the average because not representative.
† Includes shocking. Excluded from averages for cutting and for shocking.

Materials Used in Corn Production

The varieties of corn most commonly planted were Northwestern Dent and an early strain of Minnesota 13. The average amount of seed per acre was 16 pounds for drilled corn and 9 pounds for checked corn. When drilled corn was cut and bound, 3.1 pounds of twine was the average amount used. The yearly average amount used per acre on checked corn varied from 1.7 pounds in 1928 to 2.7 pounds in 1927, and averaged 2.1 pounds for the three years. The differences in yearly averages were due largely to differences in yield.

Standards for Corn Production

The standards for seedbed preparation for corn are the same as those for the other crops. Standards for the other operations are indicated in Table 34. These standards contemplate a yield of 4½ tons of silage or 2 tons of fodder corn. The labor for silo filling includes that of the

tractor operator, who helps feed the silage cutter. No standard is presented for husking because the acreage of corn husked was too small to furnish an adequate basis for establishing a standard.

Table 34

Standards per Acre for Corn

Operation	Implement	Hours per acre		Acres covered per 10-hour day
		Man	Horse	
Planting, 2 horses	2-row planter	0.7	1.4	14.3
Cultivating, 2 horses	1-row cultivator	1.3	2.6	7.7
Cutting, 3 horses	1-row binder	1.4	4.2	7.1
Cutting, 4 horses	1-row binder	1.3	5.2	7.7
Shocking		2.0	...	5.0
Silo filling		7.2	7.5	...

The Northwest Experiment Station recommends 9 to 12 pounds of seed per acre if corn is drilled and 7 to 10 pounds if it is checked. Three pounds of twine per acre should be sufficient for drilled corn and 2½ pounds for checked corn.

Distribution of Labor on Corn

The dates between which the usual crop operations on corn are performed, together with the usual number of days available, are presented in Table 35.

Table 35

Usual Dates and Work Days Available for Performing Different Field Operations on Corn

Operation	Usual dates	Work days available
Seedbed preparation	May 1 to June 10	26
Planting	May 10 to June 10	18
Cultivating	June 1 to Aug. 1	33
Silo filling	Sept. 10 to Sept. 25	10
Cutting and shocking	Sept. 10 to Oct. 1	13

The daily distribution of man labor on a 30-acre field of corn is presented in Figure 30. Of the 30 acres, 11.5 acres were put in the silo and 18.5 acres cut and shocked. Twelve acres were spring plowed and the rest fall plowed. The labor for fall plowing is not shown. Planting was done on May 30 and June 2 and 3. The labor peak in September is the result of silo filling.

Sugar Beets

Usual Practices in Sugar Beet Production

Sugar beets, on the farms studied, were grown under a contract with the American Beet Sugar Company. The company contracted for the entire crop at a fixed price before the beets were seeded. The farmer procured the seed and the fertilizer, also the contract laborers, through

the company. Payment for the seed, fertilizer, and contract labor was made by permitting the company to deduct these expenses from the proceeds from the crop. The American Beet Sugar Company paid the contract laborers. The field man employed by the company supervised the contract laborers to some extent.

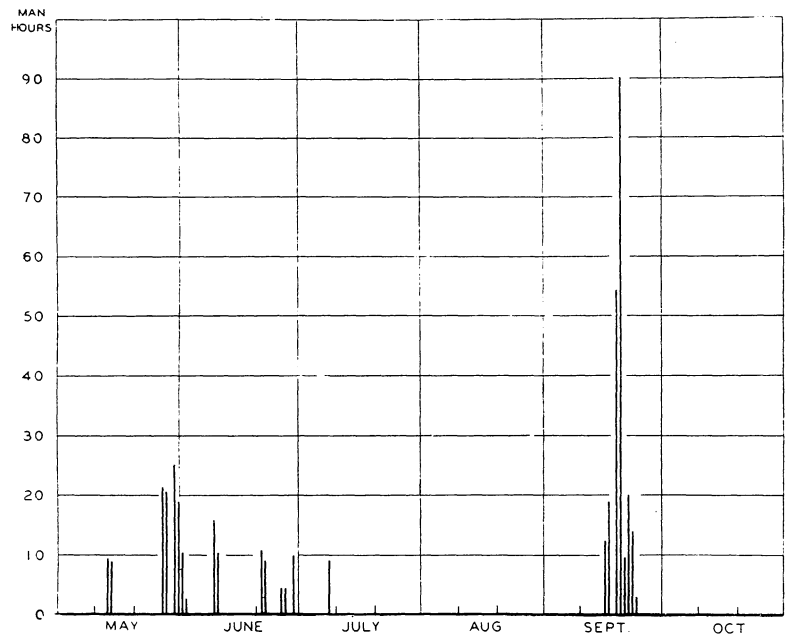

Fig. 30. Daily Distribution of Man Labor on a 30-Acre Field of Corn

The labor peak for corn comes during silo filling and fodder harvest in September. However, considerable proportion of the silo filling labor is exchange labor.

Sugar beets generally were put on the cleanest land and the seedbed was well prepared before seeding. Sixty-seven per cent of the sugar beets followed either summer fallow, potatoes, sugar beets, or corn. As a result only 38 per cent of the land was plowed. Most of the plowing was done in the fall. Approximately 20 per cent of the land was disked, most of it twice; 27 per cent was covered once with a spring-tooth harrow, a like amount was gone over twice, and 30 per cent was covered three or more times. Eight per cent of the land was covered once with an ordinary spike-tooth harrow, 31 per cent twice, 42 per cent three times, and 11 per cent more than three times. Eighty-nine per cent of the land was rolled or packed. The beet seed was drilled in with a four-row drill and fertilizer was applied in the row by means of an attachment on the drill. The number of cultivations varied from four to eight with five and six the most common. Blocking, thinning, and hoeing were done by hand by contract laborers who

were paid by the acre. These beet workers were quartered on the farms during the sugar beet season. As they were paid by the acre, every member of the family worked. Harvesting included raising the beets partly out of the ground with a horse-drawn lifter, and topping and piling were done by hand. This was done by contract laborers. Later they were loaded on wagons and hauled to the loading station at a railway siding. The tops were usually piled and used for feed.

Fig. 31. Contract Laborers in a Field of Sugar Beets

Much of the labor of hoeing, weeding, and harvesting sugar beets is hand work performed by contract laborers who are paid by the acre.

Variations in Labor Expenditures on Sugar Beets

The expenditures of man labor, horse work, and tractor work on sugar beets are presented in Tables 36 and 37. The year 1928 was selected for sugar beets as contrasted to 1927 for all other crops because the number of farms growing beets was too small in 1927 to give a typical variation in expenditures. The average expenditures were lower in 1928 than in 1926 or 1927 because of a larger proportion of the sugar beet crop being preceded by summer fallow or cultivated crops. This reduced the amount of labor necessary for proper seedbed preparation. The data on expenditures on sugar beets show a variation between farms, primarily, as a result of the factors previously discussed. However, differences of yield and distance to market were perhaps more important because of the large amount of marketing labor.

Table 36
Man Labor Used per Acre by Operations on Sugar Beets, 1928

Farm No.	Acres per farm	Yield, tons	Plowing		Disking		Spring-tooth harrowing		Harrowing		Rolling*		Seeding, hours	Cultivating, hours	Lifting, hours	Marketing, hours	Total man hours
			Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over	Hours	Times over					
029	18	9.5	0.24	0.18	....	....	0.48	1.93	0.48	1.23	0.14	0.75	0.85	5.57	2.06	7.35	17.17
111	17	10.7	....	....	1.07	2.00	0.17	0.46	1.13	2.92	.59	1.46	1.50	4.48	2.83	9.35	21.12
234	29	8.2	0.88	.58	....	....	0.39	1.61	0.77	3.00	.34	1.00	0.94	5.73	2.62	9.91	21.58
022	26	10.4	0.68	.47	0.57	0.93	0.57	1.07	0.64	1.07	.96	1.47	0.88	7.00	2.50	8.25	22.05
023	25	11.6	....	....	0.59	1.00	0.61	1.00	0.65	2.00	.35	1.00	0.83	7.68	3.11	9.95	23.77
Average																	
1928	23	10.1	0.36	.25	0.45	0.79	0.44	1.21	0.73	2.04	.48	1.14	1.00	6.09	2.62	8.96	21.13
1926	37	8.6	1.26	.56	0.46	0.88	0.99	1.70	0.86	3.21	.66	1.00	0.87	9.14	3.39	9.55	27.18
1927	22	10.7	1.35	0.55	0.12	0.21	2.46	2.17	0.58	1.84	0.70	0.96	0.98	7.92	3.43	10.48	28.02

* Includes packing and pulverizing.

Table 37
Horse and Tractor Work Used per Acre by Operations on Sugar Beets, 1928

Farm No.	Acres per farm	Yield, tons	Plowing			Disking		Spring-tooth harrowing			Harrowing			Rolling*		Seeding	Cultivating	Lifting	Marketing	Total	
			Horse hours	Tractor hours	Times over	Horse hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Tractor hours	Times over	Horse hours	Times over	Horse hours	Horse hours	Horse hours	Horse hours	Horse hours	Tractor hours
029	18	9.5	....	0.24	0.18	....	....	1.92	....	1.93	1.44	....	1.23	0.28	0.75	1.64	11.14	6.30	14.65	37.37	0.24
111	17	10.7	....	....	....	4.29	2.00	1.02	....	0.46	3.60	....	2.92	1.95	1.46	2.03	8.87	10.41	18.13	50.30	....
234	29	8.2	1.51	.28	.58	....	....	....	0.38	1.61	3.10	....	3.00	1.34	1.00	1.88	11.71	7.23	31.32	58.09	0.66
022	26	10.4	....	.68	.47	2.27	0.93	....	.57	1.07	1.25	0.33	1.07	2.38	1.47	1.68	14.00	7.48	16.33	45.39	1.58
023	25	11.6	....	....	....	2.36	1.00	2.44	....	1.00	2.40	....	2.00	1.38	1.00	1.58	15.35	9.21	39.78	74.50	....
Average																					
1928	23	10.1	0.30	.24	.25	1.78	0.79	1.08	.19	1.21	2.36	0.07	2.04	1.47	1.14	1.76	12.21	8.13	24.04	53.13	0.50
1926	37	8.6	3.81	.47	.56	1.82	0.88	3.84	....	1.70	3.37	....	3.21	2.61	1.00	1.88	19.09	10.89	25.81	73.12	0.47
1927	22	10.7	5.89	0.24	0.55	0.46	0.21	7.56	0.54	2.17	2.32	....	1.84	2.30	0.96	1.96	16.10	10.28	22.08	68.95	0.78

*Includes packing and pulverizing.

Materials Used in Sugar Beet Production

The American Beet Sugar Company has insisted upon the farmers fertilizing the land for sugar beets, and the application of 120 to 125 pounds of 16 per cent superphosphate per acre is now an almost universal practice. The amount of seed varied from 11½ to 19 pounds per acre, with an average of approximately 16 pounds. In some cases the sugar beet drill was rented from the sugar beet company at 50 cents per acre. Current rates per acre for contract labor during the period of the study were $8.00 for blocking and thinning, $6.00 for hoeing and $10 for harvesting. In addition, the contract laborers were provided a place to live and a bonus if the yield exceeded a certain tonnage. The base yield and rate for computing the bonus were established annually by the sugar company.

Standards for Sugar Beet Production

The standards for seedbed preparation for sugar beets are the same as those for the other crops. Standards for other operations are indicated in Table 38.

Table 38
Standards per Acre for Sugar Beets

Operation	Equipment	Hours per acre		Acres covered per 10-hour day
		Man	Horse	
Seeding	4-row drill	0.8	1.6	12.5
Cultivating	4-row cultivator	1.3	2.6	7.7
Lifting	1-row lifter	2.6	7.8	3.8
Hauling to market	.....	8.8	17.6	1.1

The Northwest Experiment Station recommends seeding 12 to 18 pounds of seed per acre. An application of 120 pounds of 16 per cent superphosphate per acre is recommended as a standard. Where it is necessary to poison cutworms, ½ pound of paris green and 12 pounds of bran per acre should be sufficient.

Distribution of Labor on Sugar Beets

The usual dates for performing the field operations on sugar beets, together with the approximate number of days available for field work, are given in Table 39. Adjustment must be made in any particular year for variations in the advancement of the season. No dates are given for fall plowing, as that may be done any time between harvesting and the time the ground freezes.

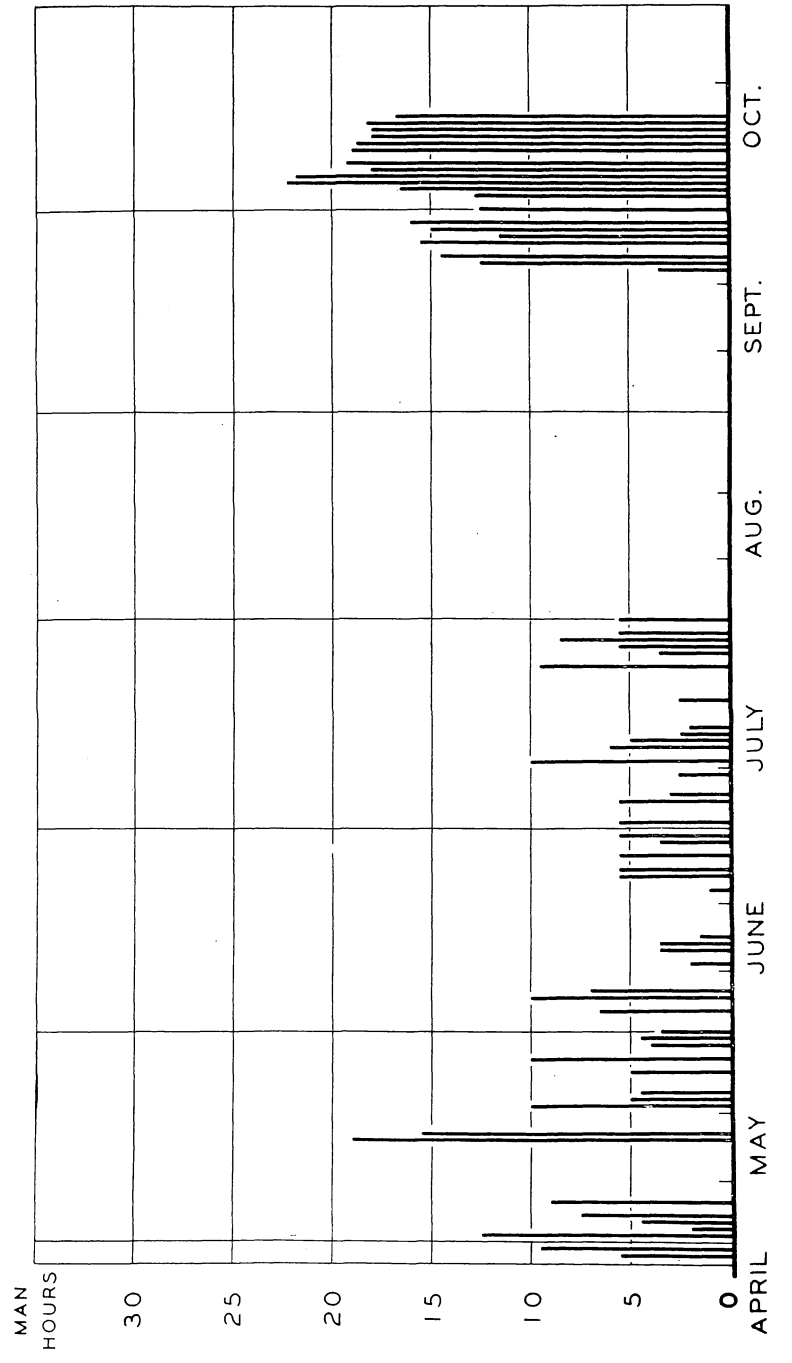

Fig. 32. Daily Distribution of Man Labor on an 18-Acre Field of Sugar Beets

With contract laborers performing much of the cultivating and harvesting work, the demands on the regular farm labor supply are not heavy except during harvest. The hours of labor performed by the contract laborers are not included with the figure.

Table 39

Usual Dates and Work Days Available for Performing Different Field Operations on Sugar Beets

Operation	Usual dates	Work days available
Seedbed preparation	April 20 to May 27	23
Seeding	April 29 to May 27	18
Cultivating	May 15 to Aug. 4	45
Harvesting	Sept. 18 to Oct. 16	18

The daily expenditure of man labor on a 18-acre field of sugar beets is indicated in Figure 32. The hours given do not include the time of contract laborers. Because the contract laborers were paid by the acre rather than on a time basis, no record was made of the number of hours they worked. The labor expenditures on sugar beets were at approximately the same time as those for potatoes and corn. However, there was no serious labor conflict between sugar beets and the other crops, such as would occur if all the work was done with regular farm labor.

Alfalfa

Usual Practices in Alfalfa Hay Production

Alfalfa is commonly seeded with one of the small grains as a companion crop. Out of 26 seedings of alfalfa during the three years, 10 were with barley, 8 with wheat, 5 with oats, 2 with flax, and one with no

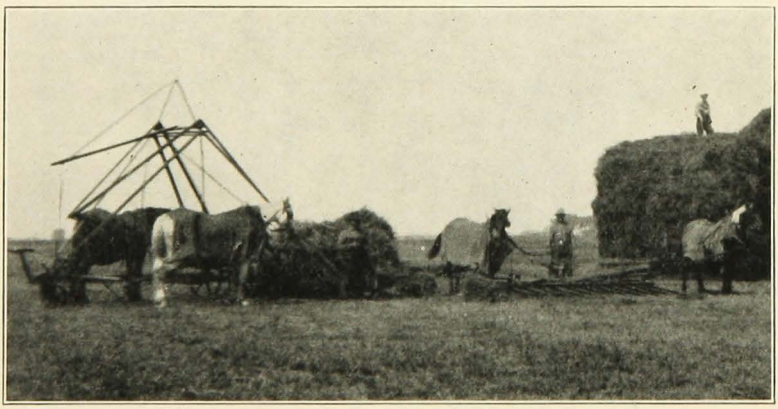

Fig. 33. Harvesting Alfalfa Hay
Hay harvest is quickly finished when a crew and equipment such as this are employed.

companion crop. Sometimes the land was given an extra working if alfalfa was to be seeded. Liming is generally unnecessary, as the soil in most of the Valley is well supplied with lime. The application of superphosphate to alfalfa is gaining in favor.

Two cuttings of hay were commonly made. In exceptional cases a third cutting was made. Approximately 43 per cent of the acreage of the first crop and 37 per cent of the second crop was hauled to the barn. Whether the hay was stacked or hauled to the barn depended largely on the distance of the field from the barn, the amount of mow space available, and the weather. Stacking was more general when fields were a considerable distance from the farmstead, when mow space was not available, or when the hay became damaged by rain. When the hay was to be hauled in, it was generally raked, then either bunched with a rake or cocked by hand and loaded by hand. Hay loaders were used on only a few farms.

When the hay was to be stacked by hand it was commonly brought in to the stack with a buck or sweep rake and pitched on the stack as long as convenient, then the stack was finished with the aid of a wagon. The hay was sometimes raked into windrows with a dump rake and then gathered from the windrow with a sweep rake. Various kinds of mechanical stackers were used on a few farms that had a large acreage of hay.

The expenditures of man labor and horse work per acre on alfalfa hay, by cuttings and by operations, are presented in Tables 40, 41, 42, and 43 for each of the farms studied in 1927. The tables also give the average for each of the three years.

Table 40

Man Labor Used per Acre by Operations on the First Cutting of Alfalfa, 1927

Farm No.	Acres per farm	Yield, tons	Mowing, hours	Raking, hours	Turning and bunching, hours	Stacking		Hauling to barn		Total man hours
						Hours	Times over	Hours	Times over	
026	15	0.61	0.68	0.61	0.41	....	....	0.99	1.00	2.69
201	22	0.84	0.73	0.39	0.78	1.80	0.43	1.07	0.57	4.77
051	36	1.10	1.17	0.32	0.13	1.45	0.62	1.76	0.38	4.83
071	9	0.48	2.52	0.95	0.17	1.35	0.77	0.11	0.23	5.10
025	7	0.84	1.01	0.65	....	3.82	1.00	....	....	5.48
081	52	0.79	1.31	0.63	0.05	0.70	0.21	2.92	0.79	5.61
161	54	1.00	1.03	0.32	0.87	0.97	0.17	2.58	0.83	5.77
023	29	0.91	1.26	0.62	0.81	2.16	0.87	1.48	0.13	6.33
233	37	0.87	1.60	0.59	0.15	3.55	0.82	0.67	0.18	6.56
031*	14	1.20	1.25	0.93	0.68	....	....	3.97	1.00	6.83
232	39	1.45	1.23	0.54	2.62	....	....	2.80	1.00	7.19
231	41	1.03	1.14	0.55	2.29	2.49	0.87	1.53	0.13	8.00
024	12	0.84	1.06	0.67	3.44	5.05	0.83	0.21	0.17	10.43
032*	8	1.38†	0.72	1.56	1.44	7.64	1.00	....	....	11.36
082	2	1.82	2.73‡	....	....	....	....	13.94	1.00	16.67
Average										
1927	27	0.97	1.34	0.53	0.90	1.79	0.51	2.31	0.49	6.87
1926	32	0.87	1.35	0.78	0.37	1.34	0.46	1.21	0.54	5.05
1928	21	0.79	1.17	0.79	0.41	1.15	0.42	1.36	0.58	4.88

* Omitted from the average because not representative.

† Includes yield of both first and second cuttings.

‡ Includes labor of raking. This farm was omitted in determining averages for mowing and raking.

Table 41
Horse Work Used per Acre by Operations on the First Cutting of Alfalfa, 1927

Farm No.	Acres per farm	Yield, tons	Mowing, hours	Raking, hours	Stacking		Hauling to barn		Total horse hours
					Hours	Times over	Hours	Times over	
026	15	0.61	1.36	1.22	....	....	1.43	1.00	4.01
201	22	0.84	1.46	0.78	2.19	0.43	2.14	0.57	6.57
051	36	1.10	2.33	0.65	1.60	0.62	1.29	0.38	5.87
071	9	0.48	5.04	1.91	0.16	0.77	0.22	0.23	7.33
025	7	0.84	2.02	1.29	4.03	1.00	....	....	7.34
081	52	0.79	2.59	1.26	0.51	0.21	3.16	0.79	7.52
161	54	1.00	2.05	1.01	0.42	0.17	3.23	0.83	6.71
023	29	0.91	2.52	1.25	2.16	0.87	2.20	0.13	8.13
233	37	0.87	3.19	1.18	4.66	0.82	0.75	0.18	9.78
031*	14	1.20	2.50	1.68	....	....	5.75	1.00	9.93
232	39	1.45	2.46	0.83	....	....	4.27	1.00	7.56
231	41	1.03	2.25	1.10	2.65	0.87	1.50	0.13	7.50
024	12	0.84	2.12	1.35	4.50	0.83	0.42	0.17	8.39
032*	8	1.38†	1.44	3.13	7.58	1.00	....	....	12.15
082	2	1.82	4.55‡	....	....	....	16.97	1.00	21.52
Average									
1927	27	0.97	2.61	1.06	1.76	0.51	2.89	0.49	8.32
1926	32	0.87	2.71	1.56	1.66	0.46	1.69	0.54	7.62
1928	21	0.79	2.34	1.54	1.41	0.42	1.54	0.58	6.83

* Omitted from the average because not representative.

† Includes yields of both first and second cuttings.

‡ Includes labor of raking. This farm was omitted in the averages for mowing and raking.

Table 42
Man Labor Used per Acre by Operations on the Second Cutting of Alfalfa, 1927

Farm No.	Acres per farm	Yield, tons	Mowing, hours	Raking, hours	Turning and bunching, hours	Stacking		Hauling to barn		Total man hours
						Hours	Times over	Hours	Times over	
071	9	0.34	0.84	0.34	....	1.18	1.00	....	....	2.36
232	39	0.21	1.24	0.67	....	....	....	0.85	1.00	2.76
233	37	0.51	1.25	0.39	....	0.70	0.82	0.51	0.18	2.85
051	14	0.44	0.92	0.37	....	....	....	1.70	1.00	2.99
201	22	0.46	0.66	0.39	....	1.96	1.00	....	....	3.01
025	7	0.86	0.61	0.68	....	....	....	1.87	1.00	3.16
081	18	0.58	1.16	0.79	....	0.79	0.48	0.69	0.52	3.43
026	12	0.41	1.07	0.70	0.41	1.35	1.00	....	....	3.53
161	54	0.44	1.07	0.53	0.60	0.93	0.66	0.65	0.34	3.78
231	41	0.61	1.12	0.58	0.63	0.50	0.56	1.19	0.44	4.02
031*	13	0.70	1.16	0.83	0.70	....	....	1.74	1.00	4.43
023	16	0.51	1.25	0.77	....	1.35	0.52	1.16	0.48	4.53
032*	8	1.38†	1.20	0.54	....	3.19	1.00	....	....	4.93
024	5	0.71	1.44	0.56	2.89	4.44	1.00	....	....	9.33
082	1	1.12	3.36	1.49	....	....	....	5.60	1.00	10.45
Average										
1927	21	0.55	1.23	0.64	0.35	1.02	0.54	1.09	0.46	4.33
1926	33	0.55	1.14	0.47	0.18	0.99	0.53	0.82	0.47	3.60
1928	18	0.66	1.16	0.67	0.51	1.09	0.50	1.23	0.50	4.66

* Omitted from the average because not representative.

† Includes yields of both first and second cuttings.

Table 43
Horse Work Used per Acre by Operations on the Second Cutting of Alfalfa, 1927

Farm No.	Acres per farm	Yield, tons	Mowing, hours	Raking, hours	Stacking		Hauling to barn		Total horse hours
					Hours	Times over	Hours	Times over	
071	9	0.34	1.68	0.60	2.35	1.00	....	....	4.63
232	39	0.21	2.48	1.34	....	....	1.19	1.00	5.01
233	37	0.51	2.50	0.78	0.64	0.82	0.67	0.18	4.59
051	14	0.44	1.85	0.74	....	....	1.33	1.00	3.92
201	22	0.46	1.32	0.78	2.14	1.00	....	....	4.24
025	7	0.86	1.22	1.37	....	....	2.02	1.00	4.61
081	18	0.58	2.05	1.58	0.94	0.48	0.94	0.52	5.51
026	12	0.41	2.13	1.39	1.64	1.00	....	....	5.16
161	54	0.44	2.15	1.07	0.90	0.66	0.88	0.34	5.00
231	41	0.61	2.25	1.15	0.64	0.56	1.46	0.44	5.50
031*	13	0.70	2.32	1.66	....	....	3.17	1.00	7.15
023	16	0.51	2.51	1.54	1.61	0.52	1.41	0.48	7.07
032*	8	1.38†	2.41	1.08	3.25	1.00	....	....	6.74
024	5	0.71	2.89	1.11	3.56	1.00	....	....	7.56
082	1	1.12	4.48	2.99	....	....	3.73	1.00	11.20
Average									
1927	21	0.55	2.27	1.26	1.11	0.54	1.05	0.46	5.69
1926	33	0.55	2.32	0.94	1.29	0.53	1.12	0.47	5.67
1928	18	0.66	2.38	1.34	1.52	0.50	1.48	0.50	6.72

* Omitted from the average because not representative.
† Includes yields of both first and second cuttings.

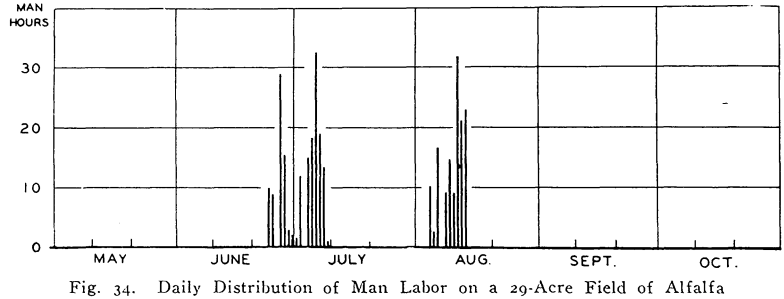

Fig. 34. Daily Distribution of Man Labor on a 29-Acre Field of Alfalfa
Two cuttings of hay were made. The first cutting may compete with corn, potatoes, and sugar beets for labor. However, the value of alfalfa justifies its inclusion in the rotation in the face of some competition.

Seeding Rates for Alfalfa

Approximately two-thirds of the alfalfa seedings were at the rate of from 10 to 13 pounds per acre. The range in the rate of seeding was from 7¾ to 20 pounds per acre. The Northwest Experiment Station recommends 10 to 12 pounds per acre.

Standards for Alfalfa Hay

The standards for alfalfa hay are presented in Table 44. They are based on an average yield of 1¼ tons for the first cutting and ¾ ton for the second.

Table 44

Standards per Acre for Alfalfa Hay

Operation	Implement	Hours per acre		Acres covered per man in a 10-hour day
		Man	Horse	
First Cutting				
Mowing	5-ft. mower	1.00	2.00	10.00
Raking	10-ft. rake	0.44	0.88	22.70
Cocking or bunching		1.25	....	8.00
Hauling to barn	With hay loader	1.60	2.15	6.40
Hauling to barn	Without hay loader	3.00	4.90	3.30
Stacking	With stacker	2.00	2.80	5.00
Stacking	Without stacker	3.15	3.50	3.18
Second Cutting				
Mowing	5-ft. mower	0.90	1.80	11.00
Raking	10-ft. rake	0.40	0.80	25.00
Cocking or bunching		1.00	....	10.00
Hauling to barn	With hay loader	1.50	1.70	6.70
Hauling to barn	Without hay loader	2.30	3.75	4.30
Stacking	With stacker	1.70	2.10	5.90
Stacking	Without stacker	2.60	2.90	3.80

Distribution of Labor on Alfalfa

The time of cutting alfalfa varies with the progress of the season and the weather. The usual dates for putting up the crop, together with the number of days available, are as follows:

First cutting	June 25–July 15	10 days
Second cutting	Aug. 1–Aug. 25	14 days

In Figure 34 is presented the daily labor distribution on a 29-acre field of alfalfa from which two cuttings were taken. The labor on alfalfa conflicts with the work on corn, potatoes, and sugar beets. Because of the demands of these other crops, haying is sometimes delayed, with resulting deterioration of the quality of the hay.

Sweet Clover

Usual Practices in Sweet Clover Production

Sweet clover grows well on most soils in the Valley. Liming is rarely necessary. On the farms studied, sweet clover was always seeded with a companion crop. Thirty-nine per cent of the seedings were with oats, 26 per cent with wheat, 21 per cent with barley, 8 per cent with flax, and 6 per cent with miscellaneous crops. The sweet clover was usually plowed under some time during the second summer and the land then fallowed. In most cases the growth was either pastured or cut for hay or both. In a few cases the entire season's growth was plowed under in June or July and then the land fallowed. On several farms the hay was cut and bound with a grain binder, much the same as a grain crop. After curing, the bundles were either stacked or hauled to the barn. In general, sweet clover was allowed to become too mature

before cutting. As a result the hay was not of so good quality as it would have been with earlier cutting. On several farms the sweet clover was allowed to mature and a crop of seed was harvested.

The amount of seed used per acre varied from approximately 9 to 18 pounds with a three-year average of 11.2 pounds. The soil was not limed on these farms. Threshing charges approximated 15 cents per bushel.

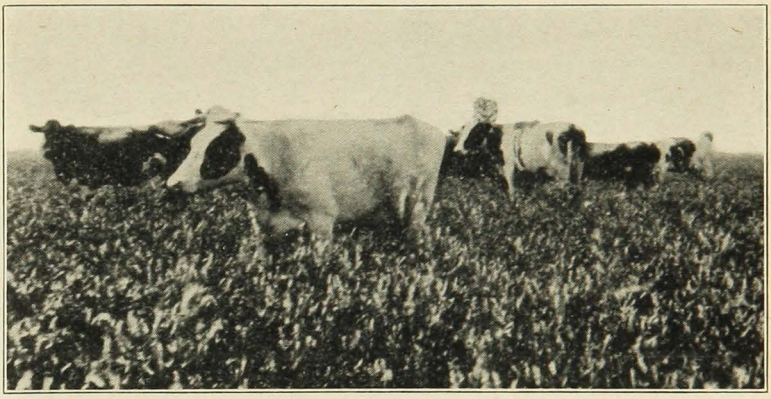

Fig. 35. A Sweet Clover Pasture in the Red River Valley
Sweet clover in the rotation aids in weed control, provides a good pasture for livestock, and may serve as a source of hay.

Standards for Sweet Clover Hay

The standards for harvesting sweet clover hay with a mower are the same as those for the first crop of alfalfa hay. The standard for cutting with a binder is the same as for flax, and hauling or stacking the bundles is the same as for hauling or stacking the first crop of alfalfa. It would, of course, be impracticable to use a hay loader or mechanical stacker with the bound bundles. The Northwest Experiment Station recommends planting 10 to 12 pounds of scarified seed or 15 to 20 pounds of unscarified seed per acre. It seems that 2¾ pounds of twine per acre should be sufficient for an average yield.

The labor distribution for sweet clover hay is similar to that for the first cutting of alfalfa hay.

Wild Hay

Usual Practices in Wild Hay Production

Wild hay is usually grown only on land not suited to other crops. The soil may be too wet, too sandy, or deficient in some other respect for seeded crops. Only one cutting of upland wild hay was made and usually only one cutting of low-land or slough hay was taken. However, a second cutting was occasionally made on small areas where mois-

ture conditions were particularly favorable for growth of a second crop. A somewhat larger proportion of wild hay than of alfalfa was stacked. This was largely because the wild hay fields were usually located at a greater distance from the buildings and wild hay keeps better in the stack than alfalfa. Wild hay was not ordinarily hand cocked.

The expenditures of man labor and horse work per acre on wild hay for each of the farms studied in 1927 and the average for each of the three years are given in Tables 45 and 46. The data in the tables indicate a distinct relationship between the yield and the amount of labor used after the hay was mowed. As the yield increased, the labor expenditure for putting up the crop also increased.

Fig. 36. A Wild Hay Field in the Red River Valley
Wild hay is harvested from land which because of lack of drainage or low fertility would otherwise be waste. Harvesting methods often conserve labor, but waste some hay.

Table 45
Man Labor Used per Acre by Operations on Wild Hay, 1927

Farm No.	Acres per farm	Yield, tons	Mowing, hours	Raking, hours	Stacking		Hauling		Total man hours
					Hours	Times over	Hours	Times over	
026	67	0.48	1.16	0.54	1.21	0.93	0.06	0.07	2.97
071	183	0.44	1.22	0.77	1.26	0.90	0.28	0.10	3.53
232	48	0.61	1.81	0.77	1.87	0.88	0.09	0.12	4.54
021	50	0.63	1.38	0.42	2.80	1.00	....	....	4.60
161	18	0.41	1.21	0.81*	....	....	3.20	1.00	5.22
233	4	1.60	1.60	1.20	2.93	0.83	0.66	0.17	6.39
081	6	0.98	1.68	0.98	5.49	1.00	....	....	8.15
201	13	1.00	1.69	0.88	1.12	0.38	5.04	0.62	8.73
082	14	1.14	1.30	1.14	3.80	0.43	4.68	0.57	10.92
Average									
1927	45	0.81	1.45	0.83	2.28	0.71	1.56	0.29	6.12
1926	36	0.93	1.43	0.61	0.88	0.50	1.82	0.50	4.74
1928	26	0.93	1.38	0.64	1.66	0.61	0.50	0.39	4.18

* Includes 24 hours of hand spreading.

Table 46
Horse Work Used by Operations on Wild Hay, 1927

Farm No.	Acres per farm	Yield, tons	Mowing, hours	Raking, hours	Stacking		Hauling		Total horse hours
					Hours	Times over	Hours	Times over	
026	67	0.48	2.32	1.08	2.27	0.93	0.12	0.07	5.79
071	183	0.44	2.44	1.55	2.28	0.90	0.51	0.10	6.78
232	48	0.61	3.62	1.55	3.28	0.88	0.19	0.12	8.64
021	50	0.63	2.75	0.83	5.33	1.00	....	....	8.91
161	18	0.41	2.41	1.14	....	....	4.61	1.00	8.16
233	4	1.60	3.19	2.39	3.19	0.83	1.33	0.17	10.10
081	6	0.98	3.36	1.97	6.89	1.00	....	....	12.22
201	13	1.00	3.38	1.77	2.23	0.38	9.31	0.62	16.69
082	14	1.14	2.60	2.28	4.11	0.43	5.70	0.57	14.69
Average									
1927	45	0.81	2.90	1.62	3.29	0.71	2.42	0.29	10.23
1926	36	0.93	2.86	1.24	0.95	0.50	2.39	0.50	7.44
1928	26	0.93	2.75	1.28	1.97	0.61	0.77	0.39	6.77

Standards for Wild Hay

The standards for wild hay are the same as those for the first cutting of alfalfa, except that wild hay is not ordinarily cocked by hand.

Distribution of Labor on Wild Hay

Because wild hay deteriorates rather slowly, it may be cut from June 15 to September 1, altho the most usual time is during the latter part of July or in August.

The daily expenditure of man labor on a 17-acre field of wild hay is presented in Figure 37. One cutting was made in the middle of July.

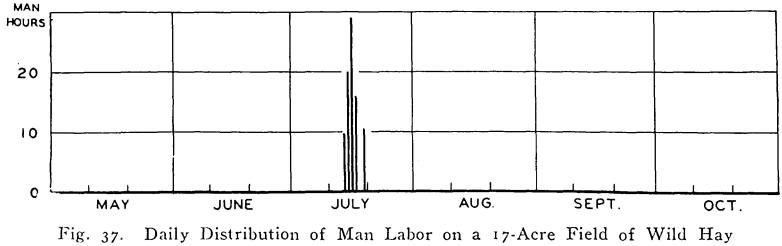

Fig. 37. Daily Distribution of Man Labor on a 17-Acre Field of Wild Hay
One cutting of wild hay is customary. Since standing wild hay deteriorates rather slowly, the harvesting of the crop is sometimes delayed until much later in the season than is here indicated.

Summer Fallow

Summer fallow, as used on the farms studied, was primarily a means of weed control and the operations were governed by what was thought necessary to accomplish this object. The operations varied from plowing and working once with a field cultivator or quack grass digger to plowing, disking, spring-tooth harrowing, and dragging. In some cases sweet clover was plowed under in June after it had attained considerable

growth and the land was not worked again until in August or September. The standards for the individual operations on summer fallow are the same as those for seedbed preparation.

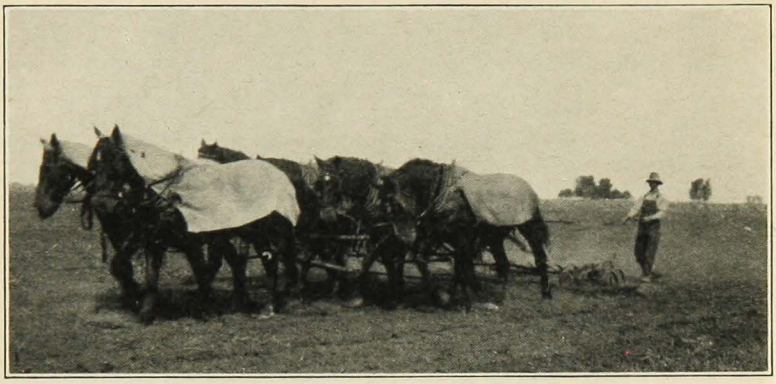

Fig. 38. Summer Fallowing With a Spring-tooth Harrow

Bare fallowing a part of the land in the farm each crop-growing season is practiced extensively in the Valley, primarily as a means of weed control. While this method of control is quite effective when properly done, it materially increases the unit cost of crop production and reduces the amount of land available for the growing of crops.

Miscellaneous Crop Labor

In addition to the regular field labor already discussed, there was also a considerable quantity of indirect or irregular labor used in crop production. This indirect and irregular work has been divided into two classes—manure hauling and miscellaneous crop labor.

Manure Hauling

Most of the manure was hauled to the fields either before the middle of June or after the first of October. Each year, approximately one-tenth of the crop acreage on the farms studied received an application of manure at an average rate of 8.5 loads per acre. Part of the land in every common crop except wild hay received manure. Twenty-nine per cent of the manure hauled out, however, was applied on land in alfalfa or sweet clover—used either for pasture or meadow, or in other seeded hay crops. Twenty per cent of it was applied on land for corn, 18 per cent on land for potatoes, and 15 per cent on land for barley. Land for each of the other crops received less than 10 per cent of the total. Because there was a smaller acreage of corn and potatoes, the proportion of the acreage in these crops receiving manure was somewhat higher. Approximately 25 per cent of the land in corn and potatoes and slightly less than that in seeded hay crops was covered with manure each year.

The annual expenditures of man labor and horse work on manure hauling, together with other related data, are presented for each of the farms studied in 1927 in Table 46.

Table 46

Man Labor and Horse Work Used for Manure Hauling, 1927

Farm No.	Crop acres per farm	Animal units per 100 crop acres	Total hours		Loads hauled	Acres covered	Hours per acre		Loads per acre	Per cent of crop acreage covered
			Man	Horse			Man	Horse		
032*	64	19	44	87	35	2	21.7	43.5	17.5	3.1
021	213	16	83	196	65	7	11.8	28.0	9.3	3.3
026	402	10	289	554	218	15	19.3	37.0	14.5	3.7
051	334	14	267	317	186	13	20.6	24.4	14.3	3.9
022	139	9	105	196	80	6	17.4	32.7	13.3	4.3
025	235	6	164	328	133	12	13.6	27.4	11.1	5.1
233	309	14	291	571	200	16	18.2	35.4	12.5	5.2
231	434	9	392	578	259	28	14.0	20.6	9.2	6.5
072	471	11	401	704	247	34	11.8	20.7	7.3	7.1
081	163	31	128	312	118	12	10.8	26.0	9.8	7.4
232	510	11	774	1400	505	40	19.3	35.0	12.6	7.9
023	264	11	354	702	196	23	15.4	30.5	8.5	8.8
201	331	10	400	717	235	34	11.8	21.1	6.9	10.7
082	191	14	284	478	194	22	12.9	21.8	8.8	11.5
161	533	10	682	1372	506	73	9.3	18.8	6.9	13.7
221	132	16	191	382	150	18	10.6	21.2	8.3	13.7
024	131	41	244	440	216	19	12.8	23.2	11.4	14.5
031*	110	29	281	672	248	47	6.0	14.3	5.3	42.7
Average										
1927	300	15	316	578	219	23	13.7	25.1	9.6	7.7
1928	313	10	298	611	257	35	8.5	17.4	7.3	11.2
1926	415	10	356	685	246	†	....	....	....	....

* Omitted from the average because not representative.

† Number of acres covered in 1926 not available.

Other Crop Labor

In addition to the regular crop labor already discussed, there was usually some indirect or miscellaneous crop work, such as cleaning up trash left on fields, cleaning grain, marketing from farm storage, inspection of fields, and raking and piling beet tops. This miscellaneous crop work averaged 261 man hours and 137 horse hours per farm per year. This was approximately 7 per cent of the total man labor and 2 per cent of the total horse work on crops.

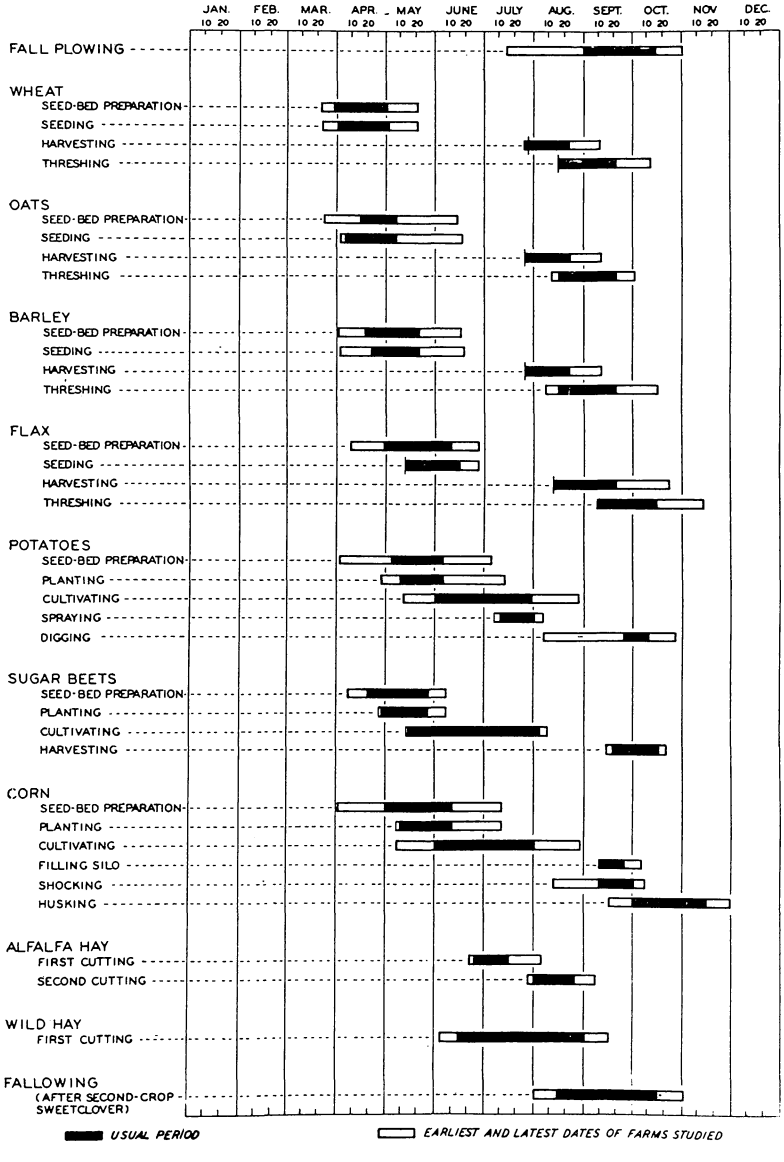

Fig. 39. The Periods for the Performance of Field-Crop Operations in the Red River Valley

Different crops use labor at different periods during the year. The small-grain crops conflict with each other some, but interfere little with the performance of labor on corn, potatoes, or sugar beets.

RELATIONS BETWEEN CROPS

The previous section was devoted to an analysis of the demands of units of the different crops for the use of the farmer's productive resources. This analysis involved the computation of basic amounts, or standards, of labor, power, and materials used for each operation, together with the direct cash outlay for contracted services and materials not ordinarily available on the farm. It involved also the selection of the usual dates for performing the different operations in the production of each of the crops. It involved further a study of the usual practices in handling the enterprise, that is, the combinations of operations most commonly used and the number of times each operation was performed. In this section, attention is directed to an analysis of the relationships between the different crops, as shown by a summary of the data presented in the preceding section. Additional supplementary and complementary relationships touched upon in discussing the problem of soil improvement are given further attention.

Proportional Demands for Use of Labor and Equipment

A knowledge of the amounts of man labor and equipment used, on units, of the different crops is essential to a consideration of the acreage of each that can be grown with a given labor supply. The data presented in the previous section on: (1) the operations most commonly performed in the production and harvest of the different crops, (2) the usual number of times each operation was performed, and (3) the standard amounts of man labor, horse work, materials, and cash outlay for contract services and materials not ordinarily available on the farm are summarized in Tables 48 and 49.

As horse power was most commonly used, only the standards for horse-drawn implements are summarized. Adjustments for the substitution of tractor power and tractor implements may be made on the basis of standards for tractor work presented in Tables 13, 14, and 15. When the preceding crop leaves the land in such a condition that an extra disking or spring-tooth harrowing may be substituted for plowing, the total labor expenditure will be reduced by the difference in the requirements for the two operations involved. The total amounts of man labor and horse work presented for the hay crops are based upon standards for handling the crops without the use of a hayloader or mechanical stacker. Owing to varying conditions, both as between different years and on different farms in the same year, it is somewhat difficult to set up standard combinations of operations, particularly for seedbed preparation. However, the data available indicate that with weed infestation no worse than average and with fairly normal soil

Table 48
Standards for Field Operations Performed with Horse Power in the Red River Valley

Hay Crops

Operation	Alfalfa (1st cut.)			Alfalfa (2nd cut.)			Sweet clover hay			Wild hay		
	Times over	Hours per acre		Times over	Hours per acre		Times over	Hours per acre		Times over	Hours per acre	
		Man	Horse		Man	Horse		Man	Horse		Man	Horse
Mowing	1	1.0	2.0	1	0.9	1.8	1	1.0	2.0	1	1.0	2.0
Raking	1	0.5	0.9	1	0.4	0.8	1	0.5	0.9	1	0.5	0.9
Bunching or hand cocking	1	1.2	...	1	1.0	...	1	1.2	...	.	...	...
Putting in barn	1	3.0	4.9	1	2.3	3.8	1	3.0	4.9	1	3.0	4.9
Stacking	1	3.2	3.5	1	2.6	2.9	1	3.2	3.5	1	3.1	3.5
Total—(barn)		5.7	7.8	.	4.6	6.4	.	5.7	7.8	.	4.5	7.8
Total—(stack)		5.9	6.4	.	4.9	5.5	.	5.9	6.4	.	4.6	6.4

Small Grain and Flax

Operation	Wheat			Oats			Barley			Flax		
	Times over	Hours per acre		Times over	Hours per acre		Times over	Hours per acre		Times over	Hours per acre	
		Man	Horse		Man	Horse		Man	Horse		Man	Horse
Plowing	1	2.0	10.0	1	2.0	10.0	1	2.0	10.0	1	2.0	10.0
Spring-tooth harrowing (or disking)	1	0.5	2.0	1	0.5	2.0	1	0.5	2.0	1	0.5	2.0
Harrowing	2	0.4	1.6	2	0.4	1.6	2	0.4	1.6	2	0.4	1.6
Seeding	1	0.5	2.0	1	0.5	2.0	1	0.5	2.0	1	0.5	2.0
Cutting	1	0.7	2.8	1	0.7	2.8	1	0.7	2.8	1	0.8	3.2
Shocking	1	0.9	...	1	0.9	...	1	1.0	...	1	0.8	...
Threshing	1	2.1	3.7	1	1.9	3.4	1	2.1	3.7	1	1.9	3.1
Total		7.1	22.1		6.9	21.8		7.2	22.1		6.9	21.9

Table 48—Contined

Standards for Field Operations Performed with Horse Power in the Red River Valley

Cultivated Crops

Operation	Potatoes			Corn silage			Corn fodder			Sugar beets		
	Times over	Hours per acre		Times over	Hours per acre		Times over	Hours per acre		Times over	Hours per acre	
		Man	Horse		Man	Horse		Man	Horse		Man	Horse
Plowing	1	2.0	10.0	1	2.0	10.0	1	2.0	10.0	1	2.0	10.0
Spring-tooth harrowing	2	1.0	4.0	2	1.0	4.0	2	1.0	4.0	2	1.0	4.0
(or disking)		(0.9)	(3.6)		(0.9)	(3.6)		(0.9)	(3.6)		(0.9)	(3.6)
Harrowing	2	0.4	1.6	2	0.4	1.6	2	0.4	1.6	2	0.4	1.6
Cutting seed	1	3.5	...	.	...	...	.	...	...	.	...	...
Rolling	.	...	...	.	...	...	.	...	...	1	0.4	1.6
Planting	1	1.8	3.6	1	0.7	1.4	1	0.7	1.4	1	0.8	1.6
Cultivating	3	3.9	7.8	4	5.2	10.4	4	5.2	10.4	6	7.8	15.6
Spraying	2	1.8	3.6	.	...	...	.	...	...	.	...	...
Digging	1	1.8	7.2	.	...	...	.	...	...	.	...	...
Picking and hauling	1	13.0	5.0	.	...	...	.	...	...	.	...	...
Cutting	.	...	...	1	1.3	5.2	1	1.3	5.2	.	...	...
Shocking	.	...	...	.	...	...	1	2.0	...	.	...	...
Silo filling	.	...	...	1	7.2	7.5	.	...	...	.	...	...
Lifting	.	...	...	.	...	...	.	...	...	1	2.6	7.8
Hauling	.	...	...	.	...	...	.	...	...	1	8.8	17.6
Miscellaneous*	.	3.8	...	.	...	...	.	...	...	.	...	...
Total		33.0	42.8		17.8	40.1		12.6	32.6		23.8	59.8

* Includes hand hoeing, weeding, and sorting the potatoes.

and weather conditions, the combinations of operations presented in Table 48 may be used as a guide. A farmer can make the comparisons more useful to himself by adjusting the standards to the conditions on his farm.

Table 49

Standard Quantities of Materials and Values of Contract Services Used for Crop Production in the Red River Valley

Crop	Production per acre	Materials per acre		Contract services	
		Kind	Quantity	Kind	Cost
Wheat	18 bu.	Seed	1½ bu.	Threshing, per bu.	$ 0.06
		Twine	2½ lb.		
Oats	42 bu.	Seed	2 bu.	Threshing. per bu.	.04
		Twine	2¾ lb.		
Barley	35 bu.	Seed	2 bu.	Threshing. per bu.	.04
		Twine	2¾ lb.		
Flax	10 bu.	Seed	½ bu.	Threshing, per bu.	.12
		Twine	2 lb.		
Potatoes	125 bu.	Seed	14 bu.*	Picking, per bu.	0.05
		Superphosphate 16%	250 lb.		
		Paris green	2 lb.		
		Lime	4 lb.		
		Copper sulphate	4 lb.		
Sugar beets, roots	10 tons	Seed	16 lb.	Thinning and blocking. per acre	8.00
tops	1 ton	Superphosphate 16%	120 lb.	Hoeing, per acre	6.00
		Paris green	½ lb.	Harvest, per acre	10.00
		Bran	12 lb.	Tonnage bonus, per acre	0.60†
Corn, grain	25 bu.	Seed, checked.	9 lb.		
Corn, stover	1¼ tons	Twine	2½ lb.		
Silage	4¼ tons	Seed	12 lb.		
		Twine	3 lb.		
Alfalfa hay	2 tons	Seed	12 lb.‡		
Sweet clover hay	1¼ tons	Seed	12 lb.		
Wild hay	1 ton				

* Potato growers near East Grand Forks commonly plant from 22 to 23 bushels per acre.

† Computed on a base-yield of 9.2 tons per acre and a rate of 75 cents per ton.

‡ The amount per year would be only 2.4 pounds on basis of the stand remaining on the same field five years.

Almost identical amounts of both man labor and horse work were used per acre on the small grains and flax. The data in Table 48 indicate that approximately 7 hours of man labor and 22 of horse work were used in growing and harvesting an acre of wheat, oats, barley, or flax. It should be remembered, however, that these amounts are standards based upon the accomplishments of the more efficient operators, as explained on page 47. Approximately equal amounts of man labor were used on sugar beets and potatoes, excluding the labor of picking the potatoes; but the amounts were about three and one-fourth times as much as were used on flax or the small grains. The amount of horse work on sugar beets, as compared with that on small grains and flax, was in about the same proportions as the amounts of man labor used on the two crops. Proportionately less horse work was used on

potatoes. Only about twice as much horse work was used on an acre of potatoes as on an acre of small grains. An acre of corn fodder received only slightly more man labor than two cuttings of alfalfa; but the amount of horse work used on corn fodder was more than double that used on alfalfa. Two cuttings of alfalfa stored in the barn occasioned the use of 10.3 man hours and 14.2 horse hours per acre, while the standard amounts for an acre of corn fodder put into the shock were 12.6 man hours and 32.6 horse hours. An acre of corn put in the silo made additional demands of 5.2 man hours and 7.5 horse hours as compared with an acre cut for fodder. In harvesting wild hay, 4.6 man hours and 6.4 horse hours were used when the hay was stacked in the field.

Ordinarily, with modern machinery, the regular labor and equipment on a farm can harvest, with the occasional assistance of extra day help, as many acres of small grain as can be prepared and seeded in the spring. With extra help for potato picking, it can cultivate and harvest about the same acreage as can be seeded during the season favorable to planting. The total amounts of labor and equipment used on different crops, together with the number of days available for work on each crop, may not always be a safe criterion, however, in determining the acreage of each crop that a given supply of labor and equipment can handle satisfactorily. Sometimes the peaks of demands for the use of these factors are more important. For example, in most cases fewer acres of sugar beets can be cared for adequately than the total labor and equipment requirements per acre and the periods available for work would indicate. The cultivations must be timed with the blocking, thinning, and weeding, which is done by contract labor. Moreover, owing to the large tonnage yielded per acre, sugar beets draw heavily upon the hauling facilities at harvest time.

Seasonality of Demands Upon Farm Resources

It is important in the interests of economy that the farmer have productive employment for his labor and equipment for the maximum portion of the working year. It is essential, therefore, that he select such crops as will dovetail together without serious conflict so far as their demands for these factors are concerned. By considering the distribution of the demands for the use of labor and equipment (see Fig. 39), the competitive relations can be determined and crops chosen which fit well together. For example, the preparation for and seeding of oats follow that of wheat in the spring; barley follows oats, and flax follows barley. At harvest time, barley ripens ahead of all other grains, wheat is ready to harvest ahead of oats, and flax follows oats. The grain crops interfere little with seedbed preparation and planting of the cultivated crops—corn, potatoes, and sugar beets. Following through the

season, the cultivation of these crops is completed ahead of grain harvest and they are harvested after the usual threshing period.

On the other hand, almost all the crops are to a degree competitive. While the preparation of the land for oats and seeding follow that of wheat, the seasonal demands for labor and equipment for these two operations are so nearly identical (see Fig. 39) that an increase in the acreage of one without an increase in the labor supply must be accompanied by a decrease in the acreage of the other. Corn and potatoes compete directly for labor and equipment. Harvesting alfalfa, sweet clover, and wild hay may conflict with the work of cultivating corn, potatoes, and sugar beets; but the hay crops provide the basis for employment of the farmer's time in feeding livestock in the winter. Hence, the farmer usually finds it desirable to hire extra day help for a short period during hay harvest.

Proportional Returns

It has been noted that most crops that are near each other in the sequence of their demands for the use of labor and equipment are to a degree competitive, because the dates within which the field operations may be performed on them somewhat overlap. To the extent to which the seasons favorable to the production of different crops coincide, any one may be substituted for another or for all others. The value returns from the different crops, after deducting direct cash outlays, are important in this connection. The farmer, who is desirous of obtaining the maximum returns from the use of his resources, will want to consider the advisability of employing his labor and equipment on the competitive crop having the highest net value return per acre to the marginal limits of the season favorable to its production. This is especially significant when considering crops having approximately the same labor, equipment, and soil requirements as, for example, the spring grains and flax, or potatoes and sugar beets.

In Table 50 is presented the cash value per acre by various crops grown in the Valley. Wheat, flax, potatoes, and sugar beets are raised almost exclusively as a cash crop. While oats and barley are grown primarily for feed, there is commonly a surplus over feeding requirements that is marketed as cash grain. On the basis of the crop yields and prices used, the figures in Table 50 indicate that among the four crops—flax, wheat, oats, and barley—flax yielded the largest cash value per acre after direct cash costs were deducted. The difference in favor of flax was $3.14 per acre as compared with wheat, $3.50 per acre as compared with barley, and $6.63 per acre as compared with oats. It has already been noted that these four crops made approximately equal demands upon man labor, horse work, and equipment. Potatoes and sugar beets used about equal amounts of man labor. Potatoes, how-

ever, yielded a 70 per cent greater cash value per acre than sugar beets. The returns from potatoes were higher than those from an acre of the small grains, with the differences in the amounts of man labor and horse work used considered. The cash value relations between potatoes and flax were favorable to potatoes. Potatoes yielded higher returns than flax per unit of labor expended and both potatoes and sugar beets yielded considerably higher returns per unit of land. With varied crop yields and with prices changed, the cash values of the various crops would change accordingly.

Table 50
Cash Value Yielded per Acre by Various Red River Valley Crops

Item	Crop					
	Wheat	Oats	Barley	Flax	Potatoes	Sugar beets
Standard yield, bu. or tons*	18.0	42.0	35.0	10.0	125.0	10.0
Amount seeded, bushels	1.5	2.0	2.0	0.5	14.0	....
Net yield, bushels or tons	16.5	40.0	33.0	9.5	111.0	10.0
Relative sale price	$ 0.90	$ 0.30	$ 0.45	$ 1.90	$ 0.65	$ 6.50
Gross cash value	14.85	12.00	14.85	18.05	72.15	65.00
Direct cash costs:†						
Threshing	1.08	1.68	1.40	1.20	.....	.....
Picking	.....	.....	.....	.....	6.25	.....
Thinning and blocking	.....	.....	.....	.....	.....	8.00
Hoeing	.....	.....	.....	.....	.....	6.00
Topping and piling	.....	.....	.....	.....	.....	10.00
Tonnage bonus	.....	.....	.....	.....	.....	0.60
Twine	0.32	0.36	0.36	0.26	.....	.....
Seed	.....	.....	.....	.....	.....	2.40
Superphosphate 16 per cent	.....	.....	.....	.....	4.38	2.10
Copper sulfate	.....	.....	.....	.....	1.00	.....
Paris green	.....	.....	.....	.....	0.70	0.18
Lime	.....	.....	.....	.....	0.04	.....
Bran	.....	.....	.....	.....	.....	0.17
Total cash costs	1.40	2.04	1.76	1.46	12.37	29.45
Cash value after deducting direct cash costs	$13.45	$ 9.96	$13.09	$16.59	$59.78	$35.35
Hours of man labor used	7.1	6.9	7.2	6.9	24.0	23.8
Hours of horse work used	22.1	21.8	22.1	21.9	42.8	59.8

* Standard yields are those that might be expected if these crops were grown in a rotation using recommended varieties and following good cultural practices.

† The prices used in computing cash costs were: Threshing: wheat 6 cents, oats 4 cents, barley 4 cents, and flax 12 cents per bushel; picking potatoes, 5 cents per bushel; twine, 13 cents per pound; sugar beet seed, 15 cents per pound; superphosphate, 16 per cent, $1.75 per cwt.; copper sulfate, 25 cents per pound; paris green, 35 cents per pound; lime, 1 cent per pound; bran, $1.40 cwt.

In planning for the feed crops that he will grow, the farmer must consider not only differences in amount of feeds that can be obtained from an acre of the crops commonly grown in the Valley, but also differences in the feeding value of the various crops as measured by unit content of digestible nutrients. The feeding value of the crops, based on standard yields per acre and average analyses, is indicated in Table 51. Alfalfa leads all other crops in yield of total digestible nutrients

per acre. This is partly on account of its greater tonnage, but the great superiority of this crop in particular and of legumes in general over non-legume crops as feeds for animals adapted to consuming roughage is in their higher content of digestible protein. Sweet clover hay ranks below corn silage in total digestible nutrients, but the difference in favor of an acre of silage is largely, if not entirely, offset by the larger amount of digestible protein yielded by sweet clover hay. An acre of corn and an acre of barley have approximately equal feeding value. Both have a marked advantage over oats and wheat. A 33-bushel crop of barley contains 38 per cent more digestible nutrients than a 40-bushel crop of oats and 61 per cent more than a standard crop of wheat. Sugar beet tops have a feeding value about two-thirds that of corn silage, pound for pound.

Table 51
Feeding Value Yielded per Acre by Various Red River Valley Crops

Crop	Yield per acre less seed†		Pounds of feed	Digestible matter available as feed*		Production costs		
				Total digestible nutrients	Digestible protein	Hours man labor	Hours horse work	Direct cash costs
Barley								
Grain	33	bu.	1,584	1,256	142			
Straw‡	1	ton	2,000					
Total				1,256	142	7.1	22.1	$1.76
Oats								
Grain	40	bu.	1,280	910	124			
Straw‡	1¼	tons	2,500					
Total				910	124	6.9	21.8	2.04
Wheat								
Grain	16½	bu.	990	784	87			
Straw‡	1	ton	2,000					
Total				784	87	7.1	22.1	1.40
Corn fodder								
Grain	25	bu.	1,600	1,297	114			
Stover§	1¼	tons	2,500	385	18			
Total				1,682	132	12.6	32.6	1.15
Corn silage	4¼	tons	8,500	1,428	102	17.8	40.1	1.50
Sugar beet tops	1	ton	2,000	146	14	....	....	....
Alfalfa hay	2	tons	4,000	2,064	436	10.3	14.2	0.84‖
Sweet clover hay	1¼	tons	2,500	1,267	268	5.7	7.8	1.20
Wild hay	1	ton	2,000	964	60	4.5	7.8	....

* Based on average analyses given in "Feeds and Feeding." by Henry and Morrison.

† Based on data in Table 49.

‡ Barley straw, oat straw, and wheat straw furnish so little digestible matter that they are seldom used as feeds except to allow livestock access to the stacks in addition to regular feeding; for this reason their digestible nutrients are disregarded here.

§ The original feeding value of stover has been adjusted for losses occasioned by weathering under the usual methods of handling the crop, and by failure of the animals to consume the whole plant. The figures given here for digestible matter in the stover available as feed are not more than one-third of the original feeding value.

‖ Seed cost is based upon the assumption that the stand will remain on the same field for five years.

Additional Supplementary and Complementary Relations

It has already been noted how crops may supplement one another with reference to the use of labor and equipment, because of the seasonality of their demands. Another important aspect of this relation is in the use of land. It is known that plant food becomes available in the soil at a rate somewhat slower than the capacity of plants to withdraw it. But it is known, also, that crops are essentially different in their plant food requirements. Thus, by placing a different crop on a field each succeeding year each crop is able to draw from the land increments of its requirements somewhat in proportion to the rate at which the elements are made available through the chemical, physical, and biological reactions within the soil. Moreover, some fields are more badly infested with weeds and some crops, notably legumes and intertilled crops, are able to produce efficiently in competition with the weeds.

Legumes and cultivated crops not only supplement the small-grain crops by producing efficiently in competition with weeds and other conditions adverse to small grains, such as a compact soil and cereal disease infestation, but they are also complementary, that is, they make a contribution to the production of the other crops, because they improve soil conditions and eradicate weeds, thereby increasing the efficiency of production of subsequent crops. On the other hand, legumes frequently receive protection from the small grain when used as a companion crop. The cultivation of potatoes and sugar beets may partially prepare the land for seeding a small grain. All the feed crops and the livestock enterprises have this interdependent relation one to the other.

It is evident that the farmer, in arranging his cropping system, must have in mind a variety of crop relationships, some conflicting, others supplementary, and still others that are complementary. In a general discussion these competing, complementary, and supplementary relationships do not all lend themselves to exact measurement. Their importance, however, in a consideration of the most profitable utilization of the resources of a particular farm, is obvious. They are much more tangible when localized to the specific conditions on any farm.

SUGGESTIONS ON CROPPING SYSTEMS

The primary interest in an economic analysis of crop production is to devise a cropping system or systems that will contribute, along with the livestock enterprises, to maximum returns from the use of the farmer's resources, that is, his land, equipment, labor, materials, and managerial attention. We are now in position to view the economy of the use of these factors in crop production in the Valley and on the

basis of the foregoing analysis to make some suggestions as to wherein some readjustments can be made which promise to result in greater returns. These readjustments may involve changes in either the choice of crops grown, the proportions between the acreages of the different crops, or the practices used in the process of crop production, or perhaps in all three.

Several considerations already mentioned suggest the advisability of some modifications of, first, the choice of crops grown in some instances and, second, the proportions between the acreages of the various crops on many more farms. Chief among these considerations, or problems, are: (1) the control of weeds, (2) the control of diseases, (3) the improvement of the soil, (4) better drainage, and (5) the adjustment to the relatively low price of wheat occasioned by intense regional competition.

The analysis of these difficulties standing in the way of greater crop returns, together with the best methods of controlling and gradually overcoming them, indicates that their solution is embodied largely in the addition of more acres of legumes and intertilled crops to the cropping systems. A cropping system containing a liberal acreage of sweet clover and cultivated crops, when supplemented with late summer fallow following the second-year crop of sweet clover and early fall plowing of the stubble fields, will control weeds and many of the plant diseases which carry over in the soil. Alfalfa can also be depended upon to eradicate weeds if allowed to stand on the same field for several years. Furthermore, legumes in the rotation, especially sweet clover, assist in securing better drainage and aeration of the soil through their deep-rooting qualities and they are an assurance that the soil will be built up and afterwards maintained in good physical condition and a high rate of fertility.

The problem of adjusting crop acreages to the low level of wheat prices would be somewhat automatically taken care of by the modifications essential to the solution of the problems discussed above. In the process of adding more acres of legumes and intertilled crops, the acreage on the farm available for wheat and other small grains would be decreased and conditions favorable to lower production costs for wheat would be provided. Thus, with a smaller proportion of the farm devoted to wheat, the risk from occasional low wheat prices would be lessened and with the conditions necessary for obtaining better yields provided, wheat grown in the Valley can compete on a much more favorable basis with wheat grown in the regions adapted to lower-cost methods of production, but returning lower yields.

Crop Rotations

These problems of crop production can ordinarily be met most effectively through the adoption of a crop rotation system—a crop production program extending over a series of years which provides for the growing of approximately equal acreages of selected crops, or groups of crops each year and the shifting of these from field to field in a regular order so that each portion of the cultivated area of the farm is used at least once for each crop, or groups of crops, in the period of the rotation cycle. The number of years required to complete the rotation cycle corresponds to the number of crops and groups of crops in the rotation system. On the completion of one rotation cycle the succession is repeated.

Four different crop rotations, all containing at least one field of legumes and one of cultivated crops in the course of the rotation, are recommended by the Northwest Experiment Station for farms of different sizes and keeping different amounts of livestock.[11]

Suggested Crop Rotations for the Red River Valley

For the medium sized farm with livestock

1. Wheat
2. Sweet clover pasture
3. Corn, potatoes, and sugar beets
4. Oats or barley, or both
5. Alfalfa for hay[12]

For the medium sized farm with less livestock

1. Wheat
2. Sweet clover for hay and pasture
3. Corn, potatoes, and sugar beets
4. Flax
5. Oats or barley, or both

For the large sized farm with livestock

1. Barley
2. Wheat
3. Oats
4. Sweet clover pasture
5. Corn, potatoes, and sugar beets
6. Flax
7. Alfalfa[12]

For the large sized farm with less livestock

1. Barley
2. Durum wheat
3. Oats
4. Sweet clover
5. Corn, potatoes, and sugar beets
6. Flax
7. Common bread wheat

[11] Crops and Soils Handbook, Northwest Experiment Station, Crookston, Minnesota.

[12] The alfalfa is left until necessary to plow it up. It is then started upon one of the other fields and the crops from that field are transferred to the old alfalfa field.

It is expected that these rotations will be used only as a guide by individual farmers interested in making readjustments in their cropping systems as a means of solving their crop production problems. In arranging his rotation the farmer must have in mind, in addition to the considerations of maintenance of soil productivity and weed control, the various relationships between different crops discussed in the previous section. A good crop rotation should provide for, in addition to soil improvement and weed control, the maximum use of the available supply of labor, power, and equipment by spreading the demands for the use of these factors as uniformly as possible over the working year. Preference should be given to crops yielding the highest market or feeding value per acre insofar as it can be accomplished without too seriously neglecting the two important requirements of the rotation just mentioned, namely, labor distribution and maintenance of soil fertility. The sequence of crops should be such that each crop will follow the one preceding with the most favorable conditions for yield and with the minimum amount of labor for seedbed preparation.

The farmer must have in mind, also, the relationships between crops and livestock, briefly discussed as one of the complementary relationships of crops and more fully discussed in Minnesota Agricultural Experiment Station Bulletin 283, "An Economic Study of Livestock Possibilities in the Red River Valley of Minnesota." The cropping system should provide the variety and amounts of feeds needed for a suitable combination of livestock enterprises, thus reducing to a minimum the necessity for purchasing feeds.

In considering these inter-relationships between the various crops and between crops and livestock, different farmers will find that they have widely varying significance to them because situations on different farms are never quite the same. Not only do farms vary in size and in their adaptation to crops with reference to soils and markets, but farmers have different kinds and amounts of labor, power, and equipment at their command, and they themselves vary in their aptitudes for handling different crops.

With conditions varying so widely from farm to farm, more specific suggestions on crop selection and cropping practices must take into account the individual farmer's productive resources and the possibilities of these resources in the productive processes. **Application of the general conclusions and data previously set forth in this bulletin to the task of planning readjustments in cropping systems as a part of the undertaking of planning a more profitable utilization of all the resources on individual farms is discussed and illustrated in Minnesota Agricultural Experiment Station Bulletin No. 284, "Planning Systems of Farming for the Red River Valley of Minnesota."**